K/

Fine Copy

7 Vols. Mit 13 Tafeln

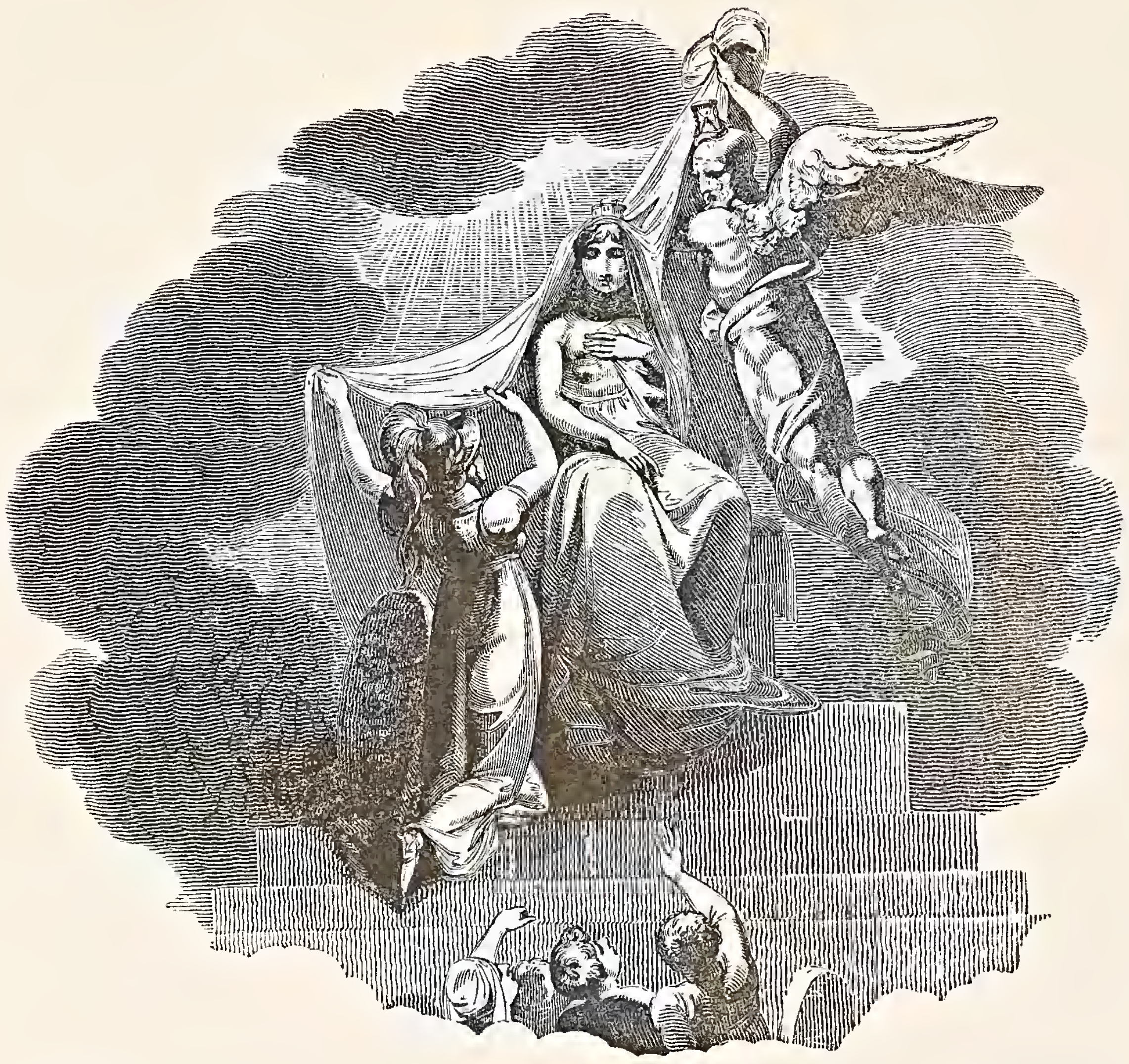
2 vols. in 1

Cost me $4.50 in Germany. 1910.

BOTANICAL EXTRACTS:

OR

PHILOSOPHY OF BOTANY.



Thurston del. TIME AND SCIENCE UNVEILING NATURE. Branston sculpt.

INCRESCUNT QUOTANNIS SCIENTIÆ, EMENDANTUR QUOTIDIE, ET AD FASTIGIUM SUUM OPTATUM SENSIM SENSIMQUE, PLURIUM VIRORUM OPERA ET STUDIO JUNCTIS, FELICITER PROPERANT.—THUNBERG.

BY

ROBERT JOHN THORNTON, M.D. F.M.S. &c.

VOL. I.

LONDON:

PRINTED BY T. BENSLEY, BOLT COURT, FLEET STREET,

FOR THE PUBLISHERS, WHITE, JOHNSON AND CO. LONGMAN AND CO. RIVINGTONS, MILLER, CADELL AND DAVIES, FAULDER, HARDING, HATCHARD, MURRAY, HIGHLEY, ASPERNE, PHILLIPS, COX, VERNOR, HOOD, AND SHARPE, SHERWOOD, NEELY, AND JONES, CONSTABLE AND CO. AND THE AUTHOR.

1810.

TO

HIS ROYAL HIGHNESS

THE PRINCE REGENT,

THIS CLASS

OF

P R I Z E S

IN THE

Royal Botanical Lottery,

IS,

WITH HIS ROYAL HIGHNESS'S PERMISSION,

AND

UNDER HIS EXPRESS PATRONAGE AND APPROBATION,

DEDICATED,

WITH UNFEIGNED GRATITUDE AND RESPECT,

BY

HIS ROYAL HIGHNESS'S

MOST OBLIGED AND DEVOTED SERVANT,

ROBERT JOHN THORNTON, M.D.

CONTENTS

OF

VOLUMES I. AND II.

B

THE Philosophy of BOTANY,

Being

Botanical, and Philosophical

Extracts.

SECT. I.

PRAISE OF THE STUDY OF BOTANY.

The spleen is seldom felt where FLORA reigns.

COWPER.

"THE tempests of WINTER are past, then SPRING advancing, her radiant brow encircled with a wreath of flowers, smiles upon the joyous earth. Her breath is sweet as the balmy breezes of the morning: her robe comprises the variegated colours of the rainbow; and her countenance is bright as the splendours with which AURORA decks the chambers of the east, when she opens the gates of the morning, before the chariot of the sun. Where'er she treads creation smiles: flowers start from under her feet, and all nature feels the renovating influence. Now, a thousand plants expand their radiant hues to the day, and throw to the soft air the most exquisite perfumes."*

"Behold, the rigid winter's o'er,
The brumal rains descend no more;
Now all around the teeming earth,
Pours forth her fair luxuriant birth;

* This beginning is an extract from the beautiful "Fugitive Pieces, intended principally for the Use of Schools," by the Rev. Dr. Collyer. The reader will find each SEASON there most elegantly personified.

And laughing Spring, with genial showers,
Awakes to life the blushing flowers:
Hark! how the feather'd chorists sing,
And, conscious, plume the trembling wing;
The nightingale, the thorns among,
Sweetly warbling, trills her song.
And now the turtle tells his tale,
Soft cooing in the humid vale;
Through ev'ry glade, through ev'ry grove,
He pours the dulcet voice of love."

—" The man
Whom nature's works can charm, with God himself
Holds converse."—

—" Some within a finer mould
Are wrought, and temper'd with a finer flame.
To these the Sire Omnipotent unfolds
The world's harmonious volume, there to read
The transcript of himself. On every part
They trace the bright impressions of his hand;
In earth, in air, the meadow's purple stores," &c.

A thousand pleasing, cheerful objects surround us on all sides. Every thing in nature seems combined to fill our minds with the sweetest and purest delights, and to lead our hearts towards God. Every object that excites our admiration inclines us to look to Him as the source and giver of all that we enjoy. Each flower is a proof of his power, a mark of his existence, and a hymn to his praise. It would have been a great instance of God's goodness to have pleased the eyes alone with the wonderful variety in the vegetable kingdom, but he has graciously added to the other charms of flowers that of sweet perfumes; and there is as much variety in their smell as in the flowers themselves.

The young mind is always delighted with rural scenery. The earliest poetry was pastoral, and every juvenile poet of the present day delights to indulge in the luxuriance of a rural description. A taste for these pleasures will render the morning-walk at least as delightful as the evening ridotto. The various forms which nature assumes in the vicissitudes of the seasons will constitute a source of complacency which can never be exhausted. How grateful to the senses the freshness of the herbage, the fragrancy of the flowers, all those simple delights of the field, which the poets have, from the earliest ages, no less justly than exuberantly described!

Every plant is formed so as to excite attention, and afford matter of astonishment and instruction; but some flowers in a more particular manner claim our consideration. There is scarcely a single object in all the vegetable world in which so many agreeable qualities are combined as in the queen of flowers, the rose. Nature certainly meant to regale the senses of her favourite with an object which presents to him at once freshness, fragrancy, colour, and shape. The very soul seems to be refreshed on the bare recollection of the pleasure which the senses receive in contemplating, in a fine vernal morning, the charms of the pink, the violet, the honeysuckle, the hyacinth, the narcissus, the jonquil, the rocket, the tulip, and a thousand others, in every variety of figure, scent, and hue; for nature is no less remarkable for the accuracy and beauty of her works, than for variety and profusion. Defects are always discovered in works of art when they are examined by a microscope; but a close examination of a leaf of a flower is like taking off a veil from the face of a beauty. The finest needle ever polished, and pointed by the most ingenious artist, appears, when it is viewed by the solar microscope, quite obtuse; while the sting of a bee, however magnified, still retains all its original acuteness of termination. The serrated border of the petal of a flower, and the fringe on the wing of a fly, display an accuracy of delineation which no person ever yet could rival. The taste of the florist has not, indeed, been much admired, or generally aspired at; while that of the connoisseur in painting is considered as a mark of elegance of character, and an honourable distinction. Yet, surely, it is an inconsitency to be transported with the workmanship of a poor mortal, and feel no raptures in surveying those highly finished pictures in which it is easy to trace the finger of the Deity.

The poets have given us most luxuriant descriptions of gardens and of rural scenery; and though they are thought by some to have exceeded reality, they have indeed scarcely equalled it. Enter only into a modern shrubbery, formed of a selection of the most agreeable flowering shrubs, and consider, whether there is any thing in the garden of Alcinous, in the fields of Elysium, in Milton's Paradise, to be compared with the intermixture of the lime, the syringa, the laburnum, the double-blossomed cherry, peach, and almond; the robinia, the jessamine, the moss-rose, the magnolia, and a great number of others, less common, but not of greater, though perhaps of equal beauty. As we walk under clusters of flowers, white as snow,

tinged with gold, purple as the grape, blue as the expanse of heaven, and blushing like the cheek of youth, we are led to imagine ourselves in fairy land, or in another and a better world, where every delicate sense is delighted, and all around breathes fragrance and expands beauty; where the heart seems to participate in the joy of laughing nature. Groves and gardens have, indeed, been always supposed to sooth the mind into a placid temper, peculiarly favourable to the indulgence of contemplation and virtue.

The universe is so full of wonders, that perhaps eternity alone can be sufficient to survey and admire them all; perhaps, too, this delightful employment may be one great part of the felicity of the blessed. If the principal delight of the soul has been in the contemplation of the beauties of the creation, and the adoration of their Almighty Author, it soars, when disembodied, into the celestial regions, duly prepared for the full enjoyment of intellectual happiness.

Nor does the advantages of the study of Botany rest only in exalting our conceptions of the Deity. "Whoever," says an ingenious writer,* "has turned his mind so as to comprehend the extensive system of the vegetable kingdom, in the manner as at present taught, and has traced this system through its various connections and relations, either descending from generals to particulars, or ascending by a gradual progress from individuals to classes, till it embraces the whole vegetable world, will by the mere exercise of the faculties employed for this purpose, acquire an arrangement, a perception of order, of distinction, and subordination, which it is not perhaps in the nature of any other study so effectually to bestow. In this view the examination of the vegetable kingdom seems peculiarly proper for youth, to whose unperverted minds the study of natural objects is always an interesting occupation, and who will not only find in this employment an innocent and an healthful amusement, but will familiarise themselves to that regulated train of ideas, that perception of relation between parts and the whole, which is of use not only in every other department of natural knowledge, but in all the concerns of life."

"Independent too of the habits of order and arrangement which will thus be established, it may justly be observed, that the bodily senses are

---

* Roscoe, of Liverpool.

SECT. II.

THE THREE KINGDOMS OF NATURE.

Hail, Sovereign Goodness! All-productive Mind!
On all thy works, thyself inscrib'd we find:
How various all, how variously endow'd!
How great their number, and each part how good!
How perfect then must the Great Parent shine,
Who, with one act of energy divine,
Laid the vast plan, and finish'd the design!

Blacklock.

Let us suppose a man just fashioned by the hands of his Creator, perfectly possessed of all his faculties, taken, to employ the allusion of Cicero *, from the profoundest cavern of the earth, and made to behold at once the wonders of creation. We will suppose the sun just rising, and streaking with gold the clouds, the mists removing like a veil from the mountain's top; in a few minutes his effulgent rays darted every where, and

* Aristotle very well observes, ' If there were men, whose habitations had been always under ' ground, in great and commodious houses, adorned with statues and pictures, furnished with every ' thing, which they, who are reputed happy, abound with; and if, without stirring from thence, they ' should be informed of a certain divine power and majesty, and after some time the earth should ' open, and they should quit their dark abode to come to us; where they should immediately behold ' the earth, the seas, the heavens; should consider the vast extent of the clouds, and force of the ' winds; should see the sun, and observe his grandeur and beauty, and perceive that day is occasioned ' by the diffusion of his light through the sky; and when night has obscured the earth, they should ' contemplate the heavens bespangled and adorned with stars; the surprising variety of the moon, in ' her increase and wane; the rising and setting of all the stars, and the inviolable regularity of their ' courses; when,' says he, ' they should see these things, they would undoubtedly conclude that ' there are gods, and that these are their mighty works.' Thus far Aristotle.—Let us imagine also as great darkness as was formerly occasioned by the irruption of the fires of Mount Ætna, which are said to have obscured the adjacent countries for two days, that one man could not know another; but, on the third, when the sun appeared, they seemed to be risen from the dead. Now, if we should be suddenly brought from a state of eternal darkness to see the light, how beautiful would the heavens seem! *But, being daily accustomed to behold them, our minds are not affected, nor troubled to search into the principles of what is always in view; as if the novelty, rather than the importance of things, ought to excite our curiosity.*

Cicero on the Nature of the Gods.

discover in vegetables the foundation of the *linen* which I wear—of the *paper* which hands down to us the wisdom of ages—those *dyes* which impress on our garments their brilliant colours. To plants I am indebted for the *wood* which warms me in the winter, kindling into a blaze, resembling the sun I seem not now to want. Without *timber* my house could scarcely have been constructed; and when fashioned into *ships*, the world, which before was separated, with its produce, from me, by a vast expanse of waters, is now approached even to my very chamber. Hence I behold with still greater veneration those *trees* whose stout branches diverge on every side, yet possessing a foliage which agreeably quivers to every breeze, but whose mossy trunk shows an existence throughout ages. Under their vast shadows, listening to the songs of the inhabitants of the groves, I repose myself; leaving this retreat, I next tread over *a rich carpet of innumerable flowers, whose varied enamel yet fixes the tender regards of that old man, who has so much and so often admired it in his youth.*"

The beauties of nature, even those which feast the eye, are inexhaustible! The colour of plants how friendly! Earth is brown, and the heavens blue—was vegetation more inclined to the brown, would it be seen? and were it blue, would it not be confounded with the waters and the sky—all either earth, or water, or sky? Throughout the magnificent picture of creation, what a happy contrast with this brown hue and azure sky do the shades of green and red afford. The verdure smiles, and the flowery carpet, intermingled with varied forms, produces a dress which never tires.

Thus nature relieves the vegetable world, and charms us with her elegance in a vast variety of forms—hence every object pleases, every object interests us, enraptured not only with her bolder sketches, with the grand and the magnificent; but in all her works, minute and howsoever small, you have to admire the delicate shades and the finest strokes and touches of her pencil, together with the brightest embroidery. If the mere sight of plants delights every eye, how much more refined then must be his pleasure who views Nature through the optics of science, to effect which will be the object of the following pages.

highly improved by that accuracy and observation, which are necessary to discriminate the various objects that pass in review before them. This improvement may be carried to a degree, of which those who are inattentive to it, have no idea. The sight of Linnæus was so penetrating, that he is said never to have used a glass even in his minutest inquiries. But our own neighbourhood affords a striking instance of an individual,* who, although wholly deprived of sight, has improved his other senses, his touch, his smell, and his taste, to such a degree, as to distinguish all the native plants of this country with an accuracy not attained by many of those who have the advantages of sight, and which justly entitles him to rank with the first botanists of this kingdom.

Independent of the propriety of the creature admiring the works of the beneficent Creator, and of the advantages resulting to the individual, who attaches himself to this study, as enlarging the understanding, and rendering his mind more orderly in every concern of life, and his senses more acute, he will find that there results also from the pursuit of botany the most *heart-felt satisfaction.*

Senebier derived much of his pleasure during life, and consolation when in advanced age, from the study of plants. After explaining in the French Encyclopædia their physiology, he concludes, "It is thus that plants ever present themselves for our regards; they charm us by the beauty of their forms, the richness of their shades, and the pleasure they spread around our habitations; they alone afford delight, without leaving behind any inquietude. The heart overwhelmed with grief, the sight fatigued by exertion, find in the verdure of fields, adorned with flowers, both comfort and refreshment. Affecting spectacle! Thou calmest the anguish of the unfortunate, at the same time augmenting the happiness of those whose lot is prosperous! For us the rose kindly unfolds to our view her smiling colours. The pink at the same time flatters our sight, and our smell, by its agreeable emanations. A thousand other flowers, of different forms, every moment present themselves to our notice. Fruit-trees, after gratifying our sight, deposit into our hands the most delicious food. The waving corn and golden sheaves delight every heart. We meet with other kindly vegetables which can assuage our pain and cure our maladies. I

* Mr. Gough, of Kendal.

the whole scene at once becoming animated! After the first powerful impression from this display of the charms of nature, like our first parent*, he would arrange this beautiful assemblage in his mind, and form three classes or kingdoms of nature, the Mineral, Vegetable, and Animal.

The Mineral Kingdom in rude masses occupies chiefly the interior parts; and is obedient to the laws of attraction or aggregation, by which it increases.

The Vegetable Kingdom possesses the surface of the earth, which it clothes with verdure, imbibes nourishment from the surrounding elements, perspires by its quivering leaves, celebrates its marriages in flowers, and by this intercourse continues its several species; lives, dies, and is regenerated by seeds, preserving the aspect of nature for ever blooming.

It boasts the following tribes, Palms, kings of the earth, eminent for their prodigious height, remarkable for an unvaried, simple, perennial stem, crowned with a tuft of leaves perpetually green, and bearing the choicest fruit.

* Straight toward heav'n my wond'ring eyes I turn'd,
And gaz'd awhile the ample sky, till rais'd
By quick instinctive motion, up I sprung,
As thitherward endeavouring, and upright
Stood on my feet: about me round I saw
Hill, dale, and shady woods, and sunny plains,
And liquid lapse of murm'ring streams; by these,
Creatures that liv'd and mov'd, and walk'd, or flew,
Birds on the branches warbling; all things smil'd,
With fragrance and with joy my heart o'erflow'd.
Myself I then perus'd, and limb by limb
Survey'd, and sometimes went, and sometimes ran
With supple joints, as lively vigour led:
But who I was, or where, or from what cause,
Knew not: to speak I try'd, and forthwith spake;
My tongue obey'd, and readily could name
Whate'er I saw. 'Thou Sun,' said I, 'fair light,
'And thou, enlighten'd Earth, so fresh and gay,
'Ye Hills and Dales, ye Rivers, Woods, and Plains,
'And ye that live and move, fair creatures, tell;
'Tell, if ye saw, how came I thus, how here?
'Not of myself; by some great Maker then,
'In goodness and in pow'r pre-eminent;
'Tell me, how may I know him, how adore,
'From whom I have that thus I move and live,
'And feel that I am happier than I know.'

Milton.

Trees, the nobility of this state, they nearly vie with palms, elevate their heads above the other tribes, whom they protect from storms, and the scorching sun, and maintain on their trunks vegetables, which cannot flourish on the earth, as the misletoe, dodder, and hypocistis.

Some of these put on a quite military appearance, being armed with spines, thorns, and prickles, as the hawthorn, bramble, and holly.

Flowers, the beaux and belles of this empire, surrounding the feet of trees, tender plants of short life, displaying the most shining festive garments.

Grasses, rusticks, the most common, which cover the greatest part of the surface of the earth, constituting the multitude and strength of the vegetable kingdom.

Mosses, an inferior order, occupying the ground relinquished by the former, cherishing in their bosom seeds of the nobler plants.

Ferns, gipsies, covering the most barren lands, and carrying their seeds on their backs.

Fungusses, abjects, plants of the autumn, naked and putrescent.

The Animal Kingdom enjoys the external parts of this world; has for the most part voluntary motion; is impelled by the cravings of want, the delights of love, and the anguish of pain.

The first kingdom, then, comprehends inorganized bodies: the second, organized, but insensible: and the third, organized and sentient beings*.

Each of these Kingdoms rise one above the other. Minerals have no vessels: Vegetables have vessels for the propulsion and formation of nutritive juices: Animals have nutritive vessels, and nerves, a peculiar and distinct system, which is the cause of sensation. And when to feeling is superadded reflection, we behold Man placed at the head of the three Kingdoms of Nature,

. . . . who, not prone
And brute, as other creatures, but endu'd
With sanctity of reason, might erect

* This is nearly Linnæus's definition, which is, Lapides crescunt; vegetabilia crescunt et vivunt; animalia crescunt, vivunt, et sentiunt. That is, Minerals have increase without life; vegetables have life, but no sensations; and animals grow, live, and feel.

His stature, and upright with front serene
Govern the rest, self-knowing, and from thence
Magnanimous to correspond with heav'n,
But grateful to acknowledge whence his good
Descends, thither with heart, and voice, and eyes
Directed in devotion, to adore
And worship God supreme, who made him chief
Of all his works.

Milton.

The study of the works of creation then is the exclusive privilege of man,* for he alone, of all created beings,

Looks through nature, up to nature's God.

Pope.

* O gracious God! if so many men do not discover thee in this great spectacle, thou givest them of all nature, it is not because thou art far from any of us. Every one of us feels thee, as it were, with his hand: but the senses and passions they raise, take up all the attention of our minds. Thus, O Lord, thy light shines in darkness; but the darkness is so thick and gloomy, that it does not admit the beams of thy light. Thou appearest every where; and every where unattentive mortals neglect to perceive thee. All nature proclaims thee: but she speaks to deaf men, whose deafness proceeds from the noise and clatter they make to stun themselves. Thou art near, and within them, but they are fugitive, and wandering as it were out of themselves. Alas! thy very gifts, which should shew them the hand from whence they flow, amuse them to such a degree, as to hinder them from perceiving it. If thou wert a barren, impotent, and inanimate body, like a flower, that decays and falls to ruin; a picture, which is but a collection of colours to strike the imagination; or an useless metal that glitters; they would perceive thee, and fondly ascribe to thee the power of giving them pleasure; although, in reality, pleasure cannot be felt by inanimate matter, and animation can alone spring from thee, who art the true source of all life. If therefore thou wert a lumpish, frail, and inanimate being; a mass without any power; a mere shadow; thy fantastic nature would busy their vanity, and absorb all their mean and brutish thoughts. But because THOU art an UNKNOWN BEING, and SPIRITUAL, they perceive THEE not. The very light, that should light them, strikes them blind; like the rays of the sun, which hinder us from seeing that luminary. In fine, because thou art too elevated, and too pure in thy nature to affect gross senses, men are become like brutes, and perceive THEE not. Some men have eyes only to see shadows, truth appears a phantom to them. What's nothing, is all; and what is all, is nothing. What do I behold in all Nature? GOD every where, and still GOD alone. When I think, O Lord, that all being is an emanation from THEE, thou exhaustest and swallowest up all my thoughts. I know not what becomes of myself. Whatever is not THOU disappears; and scarce so much of me remains, wherewithal to find myself again. Who sees THEE not, never saw any thing; and who is not sensible of THEE, never was sensible of any thing! He is as if he were not. His whole life is but a dream! He is devoid of comfort! How happy he who searches, sighs, and thirsts after THEE! 'For who is like unto thee, 'O Lord? My heart melts, and my flesh faints, O God of my soul, and my eternal wealth!'

Fenelon's Demonstration of the Existence of God from a Knowledge of Nature.

SECT. III.

THE DIFFERENT KINDS OF SEED-VESSELS.

SYLPHS, as you hover on ethereal wing,
Brood the green children of parturient Spring,
Where in their bursting cells my embryos rest,
I charge you, guard the vegetable nest;
Count with nice eye the myriad seeds, that swell
Each vaulted womb of husk, or pod, or shell;
Feed with sweet juices, clothe with downy hair,
Or hang inshrin'd, their little orbs in air.

DARWIN.

As the chrysalis of the silkworm is enclosed in a golden tomb, so is the seed guarded in a similar manner.

This part is by Botanists called the *Pericarp** (PERICARPIUM), or Seed-vessel.

For the further purpose of the protection of the seed, Nature has sometimes filled this vessel with air, as in the bladder-sena, or with down, as in the bean, and cotton plant.

* The word *Pericarp* is derived from περι, around, and καρπος, the fruit, being that part which surrounds the seeds, whatever it may be; and from being more commonly a membranous body, hence the English appellation *seed-vessel,* which conveys a more confined notion than the word *Pericarp,* and hence the adoption of the word *Pericarp* in the language of Botany.

Scientific terms are indispensably necessary in the Illustration of Nature, where the objects that present themselves to our consideration are so numerous. The question therefore is not, whether we shall have terms or no, but in what manner they should be constructed so as to answer the great purpose of receiving and communicating knowledge most effectually? Now we have been long in possession of a precise and significant language invented by Linnæus, generally adopted by the learned of every country in Europe, and received in great part into the vernacular tongues of several. Can we do better therefore than to keep as close as possible to this, and to adopt the Linnæan terms themselves, as far as the structure of our language will admit, by Anglicizing his expressions. But when any Latin terms have an appropriate sense in English, it may be better to translate them, than to use what may appear pedantic expressions; so likewise, when the Linnæan terms do not well assimilate to our language, the same rule may be observed, rather than offend the ear. MARTYN.

It must be confessed that a knowledge of Botany has no necessary connexion with the nomenclature; and it is easy to conceive how an intelligent man might be a good botanist, without the

The Pericarp serves also a grander design. It contains the reservoir of nutriment for the embryo-seeds.

PERICARPS are distinguished as follows.

I. A *Capsule* (Capsula), a seed-vessel properly speaking, usually formed of several external pieces, called *valves* (valvulæ), which are joined together by their *sutures*, or borders, but cleave, or separate, at the time of maturity, when the capsule becomes dry and membranaceous, for the purpose of liberating the seeds it contains.

Upon its opening you discover in the centre the *Column* (Columna), whence arise the *Partitions* (Dissepimenta), forming the *Cells* (Loculamenta), which contain the seeds.*

The capsule usually opens at top; and we may here remark a wise contrivance in Nature. However inclined the flower, as in the crown imperial, superb lily, and poppy, the seed-vessels, as they advance towards maturity, become rigidly erect.

In the poppy, the capsule is a kind of vase, with a cover like a parapluie, reflected over the unripe seeds, which rises as they become mature, discovering the apertures of the capsule for the escape of the seeds; there being one opening to each cell.

It sometimes opens transversely, as in anagallis; at the bottom, as in triglochin; but usually longitudinally, as in the horse-chesnut.

In some plants the capsule is found to be very pulpy, although these, when ripe, preserve their distinctive character, and are sometimes of so elastic a nature, that the seeds are darted from them with great force and velocity.

If you press betwixt your fingers and thumb the capsule of the balsam,

knowledge of the meaning of any one precise term. But such a man could not become a writer, nor could he derive advantage from the labours of others. The question then is, whether three hundred years of study and observation should be lost to Botany, whether three hundred volumes of figures and descriptions should be thrown into the fire, whether the knowledge acquired by all the learned, who have consecrated their purse, their life, their time, to distant, expensive, painful, and dangerous expeditions, should be useless to their successors, and whether every one setting out from nothing, could arrive by himself at the same knowledge, that a long series of inquiry and study has spread over the mass of mankind? If not, and if the most lovely part of natural history merit the attention of the curious, let them tell me how we shall manage to make use of the knowledge heretofore acquired, if we do not begin by learning the language of the writers, and knowing to what objects the names employed by them belong. To admit therefore the study of botany, and to reject that of the nomenclature, is a most absurd contradiction. Rousseau.

* Vide Plate III. The different kinds of Seed-vessels, and their Anatomy.

the impatiens noli me tangere, the seeds will be immediately rejected with violence. The same is still more conspicuous in the spirting cucumber, where the experiment is attended with some hazard to the sight. The seeds fly from eight to ten feet. If you press the humble sorrel, the oxalis corniculata, with your hand, you will be surprised to see the seeds immediately become scattered in every direction, more than a foot's distance from the plant.

The ligneous vessels of the capsule are finely displayed in a preparation of the thorn-apple, datura stramonium, as made by maceration in water, when the skin peeling off, and the parenchymatous part dissolving into pulp, leaves the ligneous and fibrous parts entire. Beautiful examples of these are likewise to be seen in the first private cabinet perhaps in Europe for the illustration of subjects of anatomy; I mean that of Mr. Heaviside, Surgeon to his Majesty, who, with his accustomed liberality and politeness, has offered whatever might tend to assist this work. pl 32.

II. A *Silique** (SILIQUA) is a pod in which the seeds are alternately fixed to either suture, or union of the valves, or shells, the seeds hanging by a thread, or peduncle, to the two sutures. When the pod is broader than long, it is called then a *Silicle* (SILICULA), the diminutive of the last, from the seed-vessel being usually much smaller than in the other.

III. A *Legume*† (LEGUMEN), a species of seed-vessel, enclosing a number of seeds that are fastened along one suture only.

IV. A *Follicle*‡ (FOLLICULUS), a thin membranaceous seed-vessel, of one valve, opening longitudinally, or on one side, and having no apparent suture for fastening, or attaching the seeds within it.

* Siliqua is derived from *silo*, a nose turned up, from the curve in this kind of seed-vessel. When *antique*, *critique*, and *burlesque* were first introduced into our language, they were written *antick*, *critick*, and *burlesk:* had this orthography obtained, we should have put this pericarp *Silick*, and thus have avoided the French termination. I shall not contend with any one who would retain the Latin final; nor with any other who would appropriate the English term *pod* to this, exclusive of the legume. MARTYN.

† *Pod* is used for legume, silique, and silicle, indifferently; but they are so distinct, as is seen by the attachment of the seeds, that they ought not to have the same appellation. It seems best, therefore, to Anglicise the Latin terms; and with respect to this term, there is no danger of offending the English ear. MARTYN.

The word *Legume* is derived from legere, to collect, because these are usually collected by the hand.

‡ Diminutive from follis, a pair of bellows, the *Follicle* being usually swelled out with air, as in asclepias.

V. A *Drupe** (Drupa), a pulpy body, without valves, enclosing a nut or stone, with a kernel.

VI. A *Nut*† (Nux), a hard ligneous shell, without a pulpy covering.

VII. A *Pome*‡ (Pomum), a species of seed-vessel, pulpy, not enclosing a stone, in the midst of which is found a membranaceous substance, forming cells, or cavities, for containing the seeds.

VIII. A *Berry*§ (Bacca), a pulpy seed-vessel, enclosing numerous seeds, dispersed throughout the pulp.

IX. A *Strobile*|| (Strobilus), a species of seed-vessel formed of woody scales, which embrace the seeds within their bosom. No force can draw these asunder; yet, immersed in warm water, or placed near the fire, they open most freely of themselves, exhibiting the contained seeds.

We have now enumerated the several distinct forms of Pericarps, under which all others must arrange themselves. However diversified the appearances of each may be, yet must they all fall under one of these nine general heads. The utility of such distinctions we shall see hereafter.

* From δρυς, a tree, and πεπτειν to concoct, this species of pericarp ripening on the tree before it falls: the cherry, plum, and olive, are examples of this. Miller translates in consequence, Drupa, a *Plum*; but, according to Linnæus, sometimes this pericarp is dry as the almond, which perhaps would better follow the ensign of the nut, which I have ventured to consider as a seed having a pericarp. Vide note †.

† Nux, a nut, is defined by Linnæus to be a seed covered with a shell: this shell I have considered as a distinct species of pericarp, containing the nucleus, or seed, and with what propriety I leave to the candid reader.

‡ From Pomum, an apple, as it includes all the moist fruits which have the seeds lodged in a core. It cannot, however, be translated an *Apple*, as Miller has done, since it comprehends also the gourd, cucumber, &c. and the English term would be taken in too limited a sense.

§ It is distinguished from the former, the pome, chiefly by having no apparent partitions for the seeds.

|| This term, derived from στροβιλος, an artichoke, from the resemblance which this kind of seed-vessel has to its imbricated leaves, includes not only the cone of former writers, but also some other pericarps, which recede considerably in structure from that sort of pericarp, as the magnolia. To translate, as Millar has done, Strobilus a *Cone*, is improper, as giving a false general conception. Martyn.

SECT. V.

OF THE COMPONENT PARTS OF THE SEED.

.... In thy book
Was the fair model of each structure drawn,
Where every part, in just connexion join'd,
Composed and perfected th' harmonious piece,
Ere the dim speck of being learnt to stretch
Its ductile form, or entity had known
To range and wanton in an ampler space.

PITT.

THE seed is defined by Linnæus to be the end of fructification, and the beginning of a new plant; or that portion of the maternal plant which is deciduous, containing within itself the rudiments of a new vegetable.

There are several Parts noticed by Botanists which enter into the composition of the seed.

As the bean exhibits these in the clearest manner, let us examine one of them; for example, the common broad Windsor-Bean.

The pod of the bean, as you have before learnt, is a *Legume,* composed of two *valves,* which were the pieces, or shells, which the bean divides into, filled with the softest *down,* which appears, viewed by the microscope, to be a cluster of blebs, or bladders.*

When the bean-pod opens naturally, it splits from its *under border,* or suture.

The *upper suture,* which readily divides into two parts, is an assemblage of *filaments,* or vessels, to which the beans themselves are attached by a slender *peduncle,* or thread.

The *valves,* if suffered to remain a few days in the house, especially if handled, shew a beautiful organization.

* Vide the Plates of the Anatomy of the Bean. 38 52

The *vessels* turn black, and disclose their distribution throughout the valves, terminating in the sutures for the nourishment of the seeds.

These vessels may be also easily seen with the naked eye by holding the shell up before the light.

The *peduncle*, or chord, rises slender, but ends in a *broad expansion*, very succulent at first, which, as it becomes useless, withers, disclosing the *hilum*, or eye of the bean.

In the centre of the hilum runs a *vessel*, which appears to divide it in two, at the extremity of which is an *aperture*.

This *aperture*, or foramen, was discovered by Grew an hundred years ago. It is not, says he, a hole casually made, or arising from the separation of the stalk, but designed for a special purpose.

It is observable not only in the common bean, and in the scarlet bean very plainly, but is also to be found in pease, lupins, lentils, and other pulse, and many seeds not reckoned of this kind, as that of fœnugreek, goats-rue, and others, in many of which it is so small, as scarcely without the help of glasses to be discerned, and in some not without cutting off a part of the outer cover of the seed.

This pierces the *arillus*, or, what is vulgarly called, the husk of the bean.

The *arillus* may be separated into three *layers*, and has its form exactly adapted to that of the bean.

These harmonies have often called forth the admiration of the wise intentions of the Author of the World, and proved his agency, nor ought they to be slightly passed over by us his creatures, whose highest prerogative is that of contemplating the wonders of creation, and adoring its Gracious Author.

But, before we consider the form of the arillus, let us first contemplate the seed it is destined to cover.

The first thing that naturally strikes the observer, is a small projecting point, like the beak of a bird, called by Botanists from that resemblance *rostellum*,* opposed to which is a tender *projection* enclosed within the lobes, or body of the bean.

* From rostellum, a beak.

These two parts have been styled in the language of Botany *corculum,* the heart of the seed.

The projecting part, or rostellum, when it shoots into the ground in its first growth is then called the *radicle,* from the Latin RADICULA, a small root, being destined to become the root.

The other projecting part, as it mounts in air, is called the *plume* (PLUMULA), from its bearing some resemblance to a feather, the Latin for which is PLUMA.

The bean itself naturally divides into *two lobes* (LOBULI), convex exteriorly, and concave internally, which are joined together in a dove-tail manner.

If you examine the *surface* of these lobes, there will not be found the smallest inequality, all is smooth and glossy, whereas the finest polish of human ingenuity is extremely rough.

Only view the best wrought needle, it presents to your eye nothing but huge inequalities, whereas the works of the Almighty ever manifest the most astonishing perfection.

By making a transverse section along the lobes, there will be seen on the surface *small vessels* interspersed among the blebs, which, even to the naked eye, has a greener appearance than the other parts.

These were rendered very visible by Bonnet, who immersed the lobes in ink, and a transverse section being made, they appeared like so many black dots.

This organization, however, is better shewn by a longitudinal section of one of the lobes, when the *ligneous vessels* will be observed to pass in a regular direction, all terminating towards the *plume,* which is affixed to each lobe, lying under the two *shoulders,* or projections of the bean, above which was situate the hilum, or eye of the bean.

We now are able to comprehend how excellently the arillus is contrived for the protection, and containing of the seeds.

The *arillus,* viewed internally, has *two cavities* for the reception of the *two shoulders* of the bean just before explained; and under these, exactly in the centre, is another and deeper *cavity* for the reception of the *rostellum*; and, if we return from surveying the internal structure to the external, we shall readily perceive, that that part of the arillus which corresponds to the

rostellum is almost a *mere membrane,* at the apex of which was the *aperture* before noticed, the utility of which structure will afterwards be explained.

ANALYSIS.

SEEDS are therefore composed of

I. The HUSK, or *Arillus.*

II. The CHORD, or *Chorda.*

III. The EYE, or *Hilum.*

IV. The PLANTULE, or *Corculum,* made up of the
1. *Radicle,* and
2. *Plume*; and lastly,

V. The LOBULI, or *Lobes.*

PHILOSOPHICAL INQUIRIES.

SECT. VI.

I. OF THE USES OF THE SEVERAL PARTS OF THE SEED.

Come, ye soft Sylphs! who sport on Latian land;
Come, sweet lip'd Zephyr, and Favonius bland!
Teach the fine seed, replete with life, to shoot
On Earth's cold bosom its descending root;
With pith elastic stretch its rising stem,
Part the twin lobes, and fan th' aspiring gem.

DARWIN.

THE Pericarp is usually represented by Botanists as solely destined for protection, whereas its chief and primary use is the *nourishment* of the young seeds. Hence the Pericarp, or column in its centre, serves the office of placenta to the embryos, the seeds being, as we saw before, attached to them by a *thread,* or *pedicel,* which bears an analogy to the umbilical chord of the fœtus, so little do even the subordinate parts of creation lose by comparison with the higher.

This *chord* is very visible in the bean and nut, and indeed exists in every plant; but, as the embryos increase in growth, this attachment is dissolved, and *vegetable parturition* may now be said to be performed: and as the chord becomes in the child a ligament,* so the pod assumes a new appearance, and becomes a *dry husk,* and its valves separating, the seeds are dropped from within its bosom, which may not be unaptly styled a *second birth.*

* It becomes the suspensory ligament of the liver.

An objection may perhaps be started to this doctrine from the consideration of succulent and stony fruits; but these, in their early stage, have the same organization as Pericarps.

We have an example of this in the pear and the mango;* and it may be observed, that the deposit of hard, woody, or stony particles, does not take place till a considerable time after the full formation of the embryo. Young filberts, or the walnuts which we use for pickles, are also very familiar examples of the soft state of the early shell.

The woody shell may therefore be considered as a true pericarp;§ and, as the manner in which the kernel is able to escape from its enclosure is a matter of no small wonder to the contemplators of nature, it certainly deserves our present consideration.

For the escape of the seed, the hard shell, acted on by heat and moisture, and the rarefaction of the air within, and force of the struggling embryos, endeavouring "to burst their cearments," opens "its marble jaws," and this with a facility exceeding common apprehension.

For this purpose shells are like pericarps, which first seem of one valve, one entire piece, scarcely shewing even a line of separation, and then divide, as the occasion requires, into several different compartments, or pieces, but more usually into two, which might be conjectured from observing the natural division that takes place in walnuts, apricots, and other stone fruits.

Where there is neither pericarp, nor shell, for some plants are found actually to bear *naked seeds* (Semina Nuda), the *calyx*‡ then serves the office of pericarp, and increases with the growth of the embryos, and so involves them, as not unfrequently to be mistaken for real pericarps.

The ramifications of the *vessels* in the leaflets of the calyx may be made apparent by maceration in water, as the skeleton of other leaves are produced; and their conjunction with the receptacle of the seed is then very evident.

When the seed has been liberated from its foldage, water enters by the *aperture*, or foramen, before mentioned, and insinuates itself between the

* Vide the Plate representing some preparations in the superb collection of Mr. Heaviside. Pl. 32.

§ Vide note †, page 20.

‡ The Calyx is reckoned one of the parts of fructification, and will be explained hereafter. It has a double office, the protection first of the flower, next of the fruit, and it sometimes, as shewn above, performs the office of placenta, in lieu of the Pericarp.

lobes, and the *arillus*, which it raises up, and becoming absorbed, the first growth is now commenced.

To prove this use of the *aperture*, the Baron de Gleichen made the following experiment. He covered the apertures of several beans with varnish. After it was perfectly hardened, he put these beans, and those which were not so treated, into water, in which carmine had been dissolved.

The first remained four or five days without shewing the smallest change, nor was there any redness found under the arillus.

But it was quite different with the others that were not varnished.

They were full of the red liquid, and began to vegetate before the third day.

Grew, who observed this *aperture* in all seeds which have hard skins above an hundred years ago, entertained the following curious opinion respecting its *use*, as well as that of the *arillus*. His words are,

"First of all, the bean being enfolded round with its *three coats*, the sap wherewith it is fed must of necessity pass through these, by which means it is not only in a proportionate quantity, and by degrees, but also of a purer body, and possibly not without some vegetable infusion, which is transmitted to the bean. Whereas, were the bean naked, the sap must needs be not only overcopious, but crude and immature, as not being filtered through so fine a cotton as the coats must be."

"And, as they have the use of a filter for the sap to pass through, so they have the property of a containing vessel, being alike accommodated to the securer fermentation thereof, as barrels are to any fermenting liquor."

"And, as fermentation is promoted by some aperture in the vessel, so have we the *foramen* in the upper coat also contrived; that if these should be in need of some more airy particles to excite the fermentation, through this they might obtain their entry; or, on the contrary, should there be any such particles, or steams, as might damp the genuine proceeding thereof, through this again they may have easy issue; or, if by being overcopious, they should become too high a ferment, and prevent those slow and progressive degrees, as are necessary to a due vegetation. The said aperture being that, as a common passport here to the sap, with what we call the *vent hole* of the barrel is to the new tunned liquor."

The chief design of the *arillus*, however, appears to be, not the filtering of the water, for the water enters by the aperture; or, if the arillus be extremely thin, pervades it; but a wise protection for the seed, as the shell of

an egg defends the young chick; and, being indigestible, the seed passes uninjured through the bodies of animals when swallowed whole;* and, being of an oleagenous nature, it prevents a too copious influx of moisture from coming to the lobes, which are sure to rot them. This part, therefore, is not so essential to growth as was supposed by Grew, several seeds being known to germinate equally well when divested of their arillus, if placed in a soil that is not too moist.

We come now to the consideration of the *lobes*, improperly called *cotyledons* by Linnæus, from the analogy which he supposed this part bore to the COTYLEDONES in brutes.†

We will endeavour to shew that it bears a much stronger affinity with the MAMMÆ, or *breasts*, indulging that freedom of inquiry for which the present age is so remarkable.

Formerly investigation was silenced by authority. The Ipse Dixit of a great name was received with oracular veneration. The mind yielded passive obedience, and all the free scope of the understanding was shackled by a blind admiration.

But, at the same time, whilst we presume to differ with so great a genius, we do it with all due deference, not less admiring the transcendent talents of the great reformer of Botany, than the astronomer who depicts a few spots in the sun can revere the less that bright luminary.

The Author of Nature, with equal eye, watches over the infancy of the whole creation. The animal enjoys the milky fountain of its mother. The infant vegetable lives upon a similar fluid, though differently supplied.

For its use the *lobes*, which serve the office of *breasts*, form *a kind of milk*, which is conveyed to the plantule by means of the returning vessels, which descend to it from the substance of the lobes.

It is curious to observe, that even the mucilage of almonds has obtained the appellation of milk of almonds.

The liquor procured from barley, when it has germinated, is called sweet-wort, and new milk, we know, has the same soft and sweet taste.

Without this supply of balmy liquor, the plantule must inevitably have perished; its roots being then too small to absorb a sufficient quantity of bland food, and its organs too weak to assimilate it into nourishment.

* Vide Sect. VIII. on the propagation of plants.

† The cotyledones in brutes are analogous to the placenta in us, being several small placentulæ, to which the several fœtuses are attached.

Water replete with air passes through the pores of the earth, and in this manner supplies with oxygen* those lobes which lie concealed within the ground, as the bean, &c.

Most seeds, however, rise above the surface, expand their lobes to the zephyrs, and immediately, as in the lupin, they change from a pale yellow to a bright green.

So attentive is Nature to her infant progeny, that, where the lobes are small, *seminal leaves* issue from the seed upon its first expansion: and these have been called *dissimilar leaves*, from being totally unlike the leaves, which are afterwards protruded, for they possess a consistency approaching the nature of lobes, and are never found to have their borders serrated, like other leaves. Pl 14

When prepared and examined by the microscope their anatomy very nearly resembles that of the lobes.

The origin of these seed-leaves did not indeed escape that great observer of nature, our countryman Grew, who remarks, " that the dissimilar leaves for the most part are two, which first spring up, and are of a different shape from those that follow, being the very lobes of the seed itself, divided, expanded, and then advanced."

" The impediment of our comprehension thereof are the colour, size, and shape of the dissimilar leaves. Notwithstanding that, they are nothing else but the *main body* of the seed, which how I came first to know was thus:"

" First, I observed in general, that the *dissimilar leaves* were never jagged, but even edged; and seeing the even verges of the lobes of the seed hereto respondent, I was induced to think, that those so resembling might prove the same."

" Now, descending to particular seeds, I observed, first of the lupin, that, as to its colour, advancing above the ground, as it useth to do, it was always changed into a perfect green: and why might not the same, by parity of reason, be inferred of other seeds?"

" Secondly of the cucumber, whose seed, as to its colour, often appearing above ground, in its primitive white, from white it turns to yellow, and from yellow to green, the proper colour of the seminal leaf."

* The combination of air with water is very distinctly seen by means of the air-pump. If a glass containing rain water be exposed under the receiver, it will very soon shew on its surface air-bubbles; and this appearance will continue a long while, until all the bubbles burst, and the whole air be completely disengaged.

" That, as to its size, it grew but little bigger than when it first shot, whence, as I discerned the augmentation very little, we here have actually the two lobes."

" But whereas the lobes of the seed are narrow, short, and thick, how then come the dissimilar leaves to be in comparison so exceeding broad, or long and thin?"

" The question is answered thus: the dissimilar leaves are thin, because they are very broad or long, as we see many things how much they are extended in length or breadth, so much they lose in depth, which is, what here happens to the now effoliated lobes."

" This in some dissimilar leaves is very remarkable, as in those of lettuce, thorn-apple, and others, whose seeds although small, yet the lobes of these seeds growing up into dissimilar leaves, are extended an inch, and sometimes more, in length."

" The original of the dissimilar leaves thus known, we understand,"
" Why some plants have none, because the seed either riseth not, as with beans, corn, &c. Or upon rising, the lobes are little altered, as lupins pease, &c."

" Why though the proper leaves are often indented round, the dissimilar, like the lobes, are even-edged. Why though the proper leaves are often hairy, yet these are ever smooth."

" Why some have more dissimilar leaves than two, as cresses, which have six, as the ingenious Mr. Sharrock has also remarked. The reason whereof is, because the main body of the seed is not divided into two, but six distinct lobes, as I have often counted."

" But for the most part the seed is divided into two lobes, of an homogeneous nature, plainly distinguished in most kernels, as the walnut, and not with much difficulty in some of the lesser seeds, as in that of the viola lunaria, scabious, doves-foot, &c. if slipt out of their covers before they are full ripe."

It is thus with the parent animal, who possesses two or more dugs*. These serve, however, a still more important office in the vegetable world.

* The number of dugs is always proportioned by Nature to the offspring to be produced. In a litter of pigs, it may be remarked, that each pig always goes to its own dug, and never usurps that of another. Children when first born ſhew the same partiality for one breast.

The breasts serve also the office of a warm and soft pillow to cheriſh the babe. How strong and tender also is maternal affection! But faſhion has, alas! perverted this wise ordination, and children now, as soon as they come into the world, are committed to *hirelings*.

Bonnet, in order to assure himself of the utility of these parts, made the following experiments.

"I sowed," says this celebrated naturalist, "in the beginning of August, in a box filled with garden ground, some common garden beans *(Vicia Faba)*, and buck-wheat *(Polygonum Fegopyrum.)* As soon as they began to rise, I cut off with a sharp pair of scissars the lobes from several of the beans, and the seminal-leaves at the same time from several plants of buck-wheat. Others I left untouched, in order to make the necessary comparison."

"After twelve days, having measured the first leaves of the beans deprived of their lobes, I found that these were scarcely two inches in length, having nearly the same breadth; whereas those furnished with lobes produced leaves of above three inches and a half in length, with about the same width. The same difference, or one analogous, subsisted also betwixt these plants during the whole time of their growth, so that they could easily be distinguished."

"The plants untouched produced a greater abundance of flowers, more pods, and larger, than the others."

Connubial fair! whom no fond transport warms
To lull your infant in maternal arms;
Who, bless'd in vain with tumid bosom, hear
His tender wailing with unfeeling ear;
The soothing kiss and milky rill deny
To the sweet pouting lip, and glistening eye!—
Ah! what avails the cradle's damask roof,
The eider bolster, and embroider'd woof!
Oft hears the gilded couch unpity'd plains,
And many a tear the tassel'd cuſhion stains!
No voice so sweet attunes his cares to rest!
So soft no pillow as his mother's breast! DARWIN.

The spell of faſhion, we hope, however, will soon be broken, and the conduct of her Grace the Duchess of Devonshire be generally imitated, who is thus complimented by Mr. ROSCOE.

Thus late with angel grace along the plain,
Illustrious DEVON led Britannia's train,
And whilst by frigid faſhion unreprest,
She to chaste transports open'd all her breast,
Joyed her lov'd babe its playful hand to twine
Round her fair neck, or midst her locks divine,
And from the fount with every grace imbued,
Drank heavenly nectar, not terrestrial food.
Be yours the task to break the wizard charm,
At once the spell of fashion to disarm;
So shall the glorious deed your sex inspire,
All earth applaud you, and all heaven admire.

" The removal of the seminal-leaves in the buck-wheat had a still greater effect than with the beans."

" Almost all the plants of the former, which underwent that operation, perished: and those which survived the loss, remained so stinted, that, in comparison with the others, they were as the smallest dwarfs to the biggest giants, or as plants growing upon the most barren land to those flourishing in the most fruitful."

" After three weeks their height was only an inch, the length of their longest leaves but four lines, with two and a half in breadth: whereas, those possessed of their seminal-leaves had grown six inches in height, and the length of their largest leaves was twenty-seven lines, with a breadth nearly equal."

" The former did not put forth flowers before the 12th of September; whereas the others were in full bloom on the 2d."

" This on the 24th of October had arrived at only five inches in height, had no lateral branches, produced the smallest flowers, and very few, which remained steril: whereas, the others were actually two feet five inches in height, were loaded with branches, and produced abundant flowers, bearing fruitful seeds *."

As the bean seemed to be less injured by the deprivation of the lobes, Bonnet made the following experiment.

" I put," says he, " some beans in sponge full of water."

" When they began to swell, and the lobes to separate, I cut them off from that part where they were united by two small bundles of fibres to the plantule."

" These germs (consisting of the plume which presented its leaves artfully folded one upon the other, and inclined towards its other part the ra-

* This vegetable fact might teach us a lesson respecting the rearing of our own offspring. It is of great importance to be informed, that no food is so fit for the babe as that which Nature has kindly prepared for him. But the moment a child enters into the world, that instant he is crammed with gruel, pap, and other improper diet, and no wonder he should afterwards become dwarfish, distorted, pot-bellied, and unhealthy. It is in vain that this analogy be shewn to the inconsiderate.

For you no Dryads dress the roseate bower,
For you no Nymphs their sparkling vases pour;
Unmarked by you, light Graces swim the green.

It cannot, however, fail to strike those,

——whose mind the well-attemper'd ray
Of Taste and Virtue lights with purer day;
Whose finer sense, each soft vibration owns
With sweet responsive sympathy of tones. DARWIN.

dicle) I planted on the 10th of August in a pot filled with garden mould. They were buried in the earth as far as the origin of these folded leaves."

"I watered them frequently, and had the precaution of keeping them sheltered from the sun."

"The radicle, in every instance, nourished solely by the earth, pushed forth side roots, but it required twelve days before the tender leaves lifted up their heads, and expanded."

"As soon as these plants appeared sufficiently rooted, I exposed them to the sun and air, and still continued watering them: but they maintained so dwarfish an appearance, that the most experienced botanist would have been at a loss to have discovered what they were, or at any rate would have taken them for a new species of bean, remarkable for its diminutive size."

"These plants in miniature, only two inches high, with the largest leaves but five lines in length, and one in breadth, flowered on the 19th of October, but these were proportionably small, and few, and came to nothing: whereas the others of the same age, and in the same earth, were a foot and a half in height, and their longest leaflet *(foliolus)* was seven inches and a half, and five in length."

These seminal leaves, which may be called appendages to the lobes, or "effoliated lobes," serve then the same office, and prepare a similar fluid.*

* It is the sweetness of this fluid in the seminal leaves of the turnip that invites the *field slug* (Limax agrestis), which produces to the farmer oftentimes an evil incalculable. Whole ages had passed away in deploring this evil, without finding a remedy: the honour was reserved for Mr. Vagg, a farmer at Chilcompton, who first discovered a simple remedy for so great a calamity. He observed that these depredators left their dens in the still hour of night, and that in the morning were only found the horrid traces of their devastations. To destroy such a host one by one would be impossible. As plants have the wonderful property of rearing their heads afresh, when trodden down, he struck upon the useful idea of a roller, weighty enough to crush these robbers, but which at the same time might leave the young plants uninjured; and he rolled by night; and his success corresponded with his expectations, and obtained for him that reward, which this discovery entitled him to, which was three thousand pounds, collected by a general subscription among the farmers and gentlemen of the kingdom, to be paid when the secret was divulged.

The fly, called on this very account the *turnip-fly* (Chrysoméla oleràcea, quæ habitat in Europæ plantarum cotyledonibus, præsertim tetradynamarum, quas misère destruit. Lin.), is another enemy to the Seminal-leaves, which not unfrequently sweeps off in a few days whole tracks, whose destruction has much exercised the ingenuity of man.

1. Some farmers, suspecting that it was engendered in dung, have sowed their seeds in unmucked soil; and as soon as the plants have put forth the rough leaf, which is uninviting to the fly (this they style being *up*, and *drest*), have then transplanted them into the well cultivated field.

2. Others again, entertaining the same suspicions, have laid on the manure in the autumn preceding sowing, by which means this noxious quality is said to have been prevented; and this method posseses another advantage, namely, that all the seeds contained in the dung are mostly killed by the severity of winter.

In concluding this chapter, it may be proper just to mention, that Botanists have made three great classes, or divisions, of the Vegetable world, from the observance of the Cotyledons *(Lobuli)*, and Seminal Leaves *(Folia seminalia)*; and have divided Plants into

I.	MONOCOTYLEDONES,†	Plants having *one Cotyledon.*
II.	DICOTYLEDONES,‡	.... *two Cotyledons.*
III.	ACOTYLEDONES,§	.... *no apparent Cotyledon.*

We may remark in a few words concerning this method, that the distinction of classes from the number of lobes, or seminal leaves, as is done by Ray, is of all others the most unsatisfactory:

For if the unknown plant has passed, though never so little, its first stage of vegetation, so that the expansion of the lobes of the seed are no longer visible, in vain do we attempt even the first advance, and have to stop, until its ripened seeds have, in germinating, protruded its seminal leaves: and then we have again to wait until it grows up, and produces perfectly its leaves, flowers, and fruit.

3. Others, about Midsummer, wait for the first opportunity of rain, or when the heavens threaten an immediate shower, when they sow their turnip-seed; for the natural heat of the ground, aided by moisture, especially at this season, gives an uncommon quick vegetation to the seed, which will be up in a few days, and out of all danger from the fly.

4. As the sweet smell of the turnip has been thought by some to attract the fly, attempts have been made to overpower that smell by others that were found from experience to be disagreeable. Hence some strew soot and tobacco over the field when the turnips appear; and others again trail over the young turnips the boughs of the elder tree, fixed in a gait or hurdle, most usually fumigated with the smoke of burnt tobacco mixed with a small quantity of assafœtida.

5. Others, again, attempt to suffocate these insects by the smoke of burning weeds.

6. Others spread lime over the young plants, but as only covering the outer surface of the leaves, the under parts remain unprotected, and the lightest rains washing off the lime, it can be esteemed only a partial remedy.

7. As the fly in immense swarms appear in a field, and in a few days after not unfrequently take their flight to some other field, some farmers taking advantage of this, have employed the following method. As new seeds vegetate sooner than old, they make an equal mixture of the two, and sow them, in hopes that if the early plants are destroyed, the fly may take its flight before the others are in a condition to entice them; and some, for the same purpose, steep the seed for two days, and sow this, with an equal quantity of dry seed.

8. But the device of Mr. Reynolds is the most curious, who sows double the quantity of radish as of turnip seed, for the radish he found was most agreeable to the flies, who fall upon these first; and whilst they are engaged with these, the turnips get so far advanced, as to be out of all danger.

† From μονος, and Cotyledon, a cotyledon, here used for the lobe, or seminal leaf, being such plants as have one lobe, and consequently rise with only one seminal leaf.

‡ From δις, two, and Cotyledon, a cotyledon, plants whose seeds have two lobes, and generally rise with two seminal leaves. Most plants are of this kind.

§ From α, not, and Cotyledon, a cotyledon; plants whose seeds are not furnished with cotyledons, or lobes, and consequently put forth no seminal leaves. These parts, as in mushrooms, ferns, and mosses, have not as yet been ascertained, but they most probably exist in them, as well as the others.

SECT. VII.

II. THE NATURE OF OUR ATMOSPHERE.

GNOMES! with nice eye the slow solution watch,
With fostering hand the parting atoms catch.

DARWIN.

Water and *air,* says Sir Isaac Newton, composed of old worn particles and fragments of particles, would not be of the same texture and nature now as at the beginning, did not the *primitive particles* of *matter* continue *entire,* and *compose bodies* of *one* and the *same nature and texture in all ages.* The changes of corporeal things are to be placed only in the various separations and new associations of these *permanent particles.* OPTICS, page 376.

PREVIOUS to our entering into the consideration of the connexion betwixt air and vegetable life, it may be proper, for the sake of some of our readers, to contemplate first some chemical discoveries which have done honour to this age, and immortalized the names of Priestley, Cavendish, and Lavoisier.

The Hon. Mr. Boyle has considered *our atmosphere* as *one large chemical vessel,* in which an infinite number of various operations are constantly performing. In it all the bodies of the earth are continually sending up a part of their substance by evaporation, to mix in *this great alembic,* and to float a while in common. Here minerals from their lowest depths ascend in noxious vapours to make a part of the general mass; seas, rivers, and subterraneous springs, furnish their copious supplies; plants receive and return their share; and animals, that by living upon consume this general store, are found to give it back in vast quantities when they die.

The *air,* therefore, which every where presses on us, and upon which we subsist, bears very little resemblance to that *pure, simple, elementary body* generally imagined; and which is rather a substance that can be conceived, than experienced to exist.

Chemistry, however, has made of late great advances in *this curious research,* and it will soon appear that the composition of atmospherical air has been more *rigorously* determined.

Chemistry affords two general methods of ascertaining the constituent principles of bodies, the method of *analysis,** and that of *synthesis.*†

When, for instance, by combining *water* with *alkohol,* we form the species of liquor called *brandy,* we certainly have a right to conclude (by this synthesis) that *brandy* is composed of *alkohol* and *water.* And when, by distillation of *brandy,* we obtain, separate, *water,* and *alkohol* (by this analysis), our evidence of the constituent principles of *brandy* is then rendered complete; and in general it ought to be considered as *a principle* in chemical science, never to rest satisfied without *both these species of proofs.*

THE MODERN ANALYSIS

OF

ATMOSPHERIC AIR;

Or its Separation into Two Elastic Fluids, { 1. VITAL AIR. 2. AZOTIC AIR.

LAVOISIER'S EXPERIMENT.

This illustrious chemist having placed 83 *grains* of fluid *mercury* in a *retort,* adapted to a *bell-glass,* which enclosed 100 *cubical inches* of *common air,* he kept up in his furnace a constant fire, of such force, as to keep the *quicksilver* almost always at its *boiling point.*

On the second day small *red particles* began to appear on the surface of the *mercury,* which gradually increased in size and number for four or five days.

Convinced that the *calcination* of the *mercury* after that time did not go on, he extinguished the fire; and when the vessel was cool, he found in his bell-glass, instead of 100 *cubical inches of air,* only 86, and therefore *a loss* of 14 *cubical inches* of *air.*

* From the Greek word αναλυσις. The *separation* of any *compound* into its *several parts.*
† From the Greek word συνθεσις. The *putting together* the *several parts* of a *compound body.*

Now, 14 *cubical inches* of *air* weighs 7 *grains,* and the *red particles* or *calx of mercury,* being carefully collected, weighed 90 *grains.* The *mercury,* therefore, by being calcined, had acquired an *increase of weight* of 7 *grains,* the *exact weight* of *air* which seemed *lost.**

The 86 *cubical inches* of *air* remaining in the glass after this calcination was ended being examined, it was found to possess *these distinguishing properties.*

An animal being put into it was *suffocated* in a few minutes,...and when *a taper* was plunged into it, it was *extinguished,* as if it had been immersed in water.

This gas, or *air,* has been called *phlogisticated air, non-respirable air, noxious or mephitic air, impure air*; but the French chemists have preferred the term *azotic gas (lethal air)* from the Greek words α, *privative*; and ζωη, *life,* as *this air* so quickly destroys life.

LAVOISIER'S SECOND EXPERIMENT.

Having taken 90 *grains* of the *calx of mercury,* the product of the *last process,*† Lavoisier put it into a glass retort fitted to a proper apparatus for receiving aerial products.

Having applied a *much stronger heat* than in the former experiment, he observed that at first, in proportion as the *calx* of *mercury* became heated, the intensity of its colour augmented; but soon after the *calx* began gradually to decrease in bulk, and in a few minutes *its red colour altogether disappeared,* and the 90 *grains of calx of mercury* was converted into the 83 *grains* of *running mercury,* and 14 *cubical inches* of an *aerial fluid* passed over into the recipient.

Now these 14 *cubical inches* of air weighed 7 *grains,* the *exact weight* of the air *consumed* by the *calcination* of the *mercury* in the first experiment;‡ and the 83 *grains* of the *calx* of *mercury reduced*§ to a *metallic*

* The conclusion is obvious; and in the next experiment we shall find, that the 14 *cubical inches of air,* which was *absorbed* by the *mercury,* and converted it to a *calx,* was the *vital* or *respirable part* of our air.

† Not from any peculiar property of its own, but because the *vital* or *respirable part* was abstracted from it, as will be seen from the next experiment.

‡ Had the 100 *cubical inches* of atmospheric air contained a larger share of *oxygen* or *vital air, more mercury* would have been *calcined.* For *calcination,* as this experiment shews, is nothing more than the *combination* of *vital air* with *any metallic* body.

§ From the Latin word *reduco, to bring back.* *Reduction* is the bringing back a *metal converted into a calx* to its *pristine state.*

state being examiued, had *lost in weight 7 grains,* the *exact weight* of the air now obtained. *This air* possessed these *peculiar properties.*

An animal being placed in *it,* became *remarkably lively*; a *taper* burnt in it with a *dazzling splendour*; and *charcoal,* instead of consuming quietly away, as it does in common air, burnt *with a flame,* attended with a decrepitating noise, and threw out such a *brilliant light* that the eyes could hardly endure it.

This species of air was *discovered* almost at the same time by Dr. Priestley, and Mr. Scheele. Dr. Priestley gave it the name of *Dephlogisticated* or *Pure Air*; Mr. Scheele called it *Empyreal Air*; and Lavoisier first named it *Highly Respirable Air,* or *Vital Air*; and afterwards, as it forms acids, by combining with certain bodies, he adopted the term *Oxygen Gas (Acid-making Air),* from the Greek words υξυς, *sour*; and γεινομαι, *to beget**.

THE SYNTHESIS,

Or Reunion of { 1. VITAL AIR, AND 2. AZOTIC AIR.

Lavoisier then repeated the same experiments as before related, and re-combined the two elastic fluids, which he had separately obtained in the two experiments of *calcination* and *reduction,* viz. the 84 cubical inches of the AZOTIC AIR, and the 14 cubical inches of the OXYGEN AIR, and he produced from this combination an elastic fluid precisely similar in all its properties to atmospheric air, contributing in the same way to a repetition of the same experiments, and possessing exactly the same power of supporting animal life, and combustion.

* If sulphur or charcoal be burnt in oxygen or vital air, in a close vessel, and the fumes be condensed in water, this water will acquire an acid taste, and be increased in weight exactly corresponding to the weights of sulphur or charcoal consumed, and that of the oxygen air destroyed. Sulphur united thus with oxygen, the fumes being collected in water, will form vitriolic acid; and charcoal combined with oxygen, and diffused in water, will form the carbonic, or aerial acid water.

The calces of metals the French chemists call oxyds, which signifies a body impregnated with a certain quantity of oxygen, but not sufficient to render it perceptibly acid. It is from these chiefly that we obtain the pure vital air. The oxyd of manganese parts with its oxygen so readily, that if pounded and put into an iron retort with but a moderate heat from the furnace, the air will be forced from it, and passing along an iron tube, whose termination is in water, will enter into any vessel filled and inverted over the pneumatic tub, and afford the pure separate oxygen air, the just pride of modern philosophy. This air is most fit for medicinal purposes. If vitriolic acid (sulphur and oxygen) be added to the manganese in a glass vessel, the mere heat of an Argand lamp will be sufficient to produce speedily enough of pure oxygen air for the performance of chemical experiments.

CONCLUSION.

The philosopher can have no remaining doubt as to the composition of atmospheric air; but the circumstances of these experiments might appear to him more correct, though probably at the time less clear to others, were it said, that *mercury*, at a certain temperature, overcoming the *affinities* * of

It was a metallic calx that gave origin to Dr. Priestley's famous discovery of *vital air*. "On the 1st of August, 1773, I endeavoured," says this illustrious philosopher, "to extract air from *mercurius calcinatus per se*; and I presently found that, by means of a very large burning-glass, an *aerial fluid* was expelled very readily. Having got three or four times as much as the bulk of the materials, I admitted water to it, and found it was not fixed air, because water did not absorb it. But what surprised me exceedingly was, *that when a candle was put into this newly acquired air, the flame, besides being larger, burnt with considerable more splendour, and heat, than in common air; and a piece of burnt wood that had any redness in it, was rekindled and burnt away very fast, resembling by its crackling noise paper that had been dipped in a solution of nitre.*"

"I extracted," he adds, "in the same way, a quantity of *air*, with the very *same property*, from the common *red precipitate*, which had been produced by a solution of mercury in spirit of nitre, and hence I concluded that this peculiar property was derived in both instances from *nitrous particles*. I even thought that what was usually sold as the *mercurius calcinatus per se* was contaminated with *nitrous acid*. However, upon mentioning this suspicion to Mr. Waltire, he furnished me with some, which he assured me was genuine. This being treated in the same manner as the former, only by a longer continuance of heat, I extracted much more air from it than from the other. This experiment might have satisfied any other; but being at Paris in the October following, and knowing that there were several very eminent chemists in that place, I did not omit the opportunity to get an ounce of *mercurius calcinatus* prepared by Mons. Cadet; of the genuineness of which there could not possibly be any suspicion; and at the same time I frequently mentioned my surprise at *the kind of air* I had got from this preparation to Mons. Lavoisier, and several other philosophers who honoured me with their notice in that city.

"At the same time that I had obtained the air above described from the *mercurius calcinatus* and the *red precipitate*, I also procured some of the same kind from *minium*, or *red lead*. As I never made the least secret of any thing that I observed, I mentioned this experiment *also* to all my philosophic acquaintance at Paris, and elsewhere; having no idea at that time to what these remarkable facts would lead."

Lavoisier, however, was the first who turned this important discovery to account. In a late work by Dr. Priestley he says, respecting the nature of the composition of the air, "For my own part, I will frankly acknowledge, that at the commencement of the experiments recited, I was so far from having formed any hypothesis that led me to the discoveries these produced, that they appeared to me improbable when I heard of them; and when the decisive facts did at length obtrude themselves upon my notice, it was very slowly, and with great hesitation, that I yielded to the evidence of my senses. And yet, when I reconsider the matter, and compare my last experiments relating to the constitution of the atmosphere with my first discovery, I see the closest and easiest connexion between them, so as to wonder that I should not have been led immediately from the one to the other. That this was not the case, I attribute to the force of prejudice, which, unknown to ourselves, biasses not only our judgments properly so called, but even the perceptions of our senses; for we may take a maxim so strongly for granted, that the plainest evidence of sense will not entirely change, and often hardly modify, our persuasions; and the more ingenious a man is, the more effectually he is entangled in his errors; his ingenuity only helping him to deceive himself by evading the force of truth."

* If you take a bullet and divide it with a knife into two parts, provided these be smooth and rubbed together, they will strongly unite and form one whole. This is from a law impressed on matter called the *attraction of cohesion*. But should a particle of sand, or any roughness exist, the particles being divorced from each other, beyond the sphere of mutual attraction, they are no longer actuated by this law.—The attraction of cohesion in mercury, at the common temperature, hinders the admission of oxygen, for which it has an elective attraction or affinity. But when exposed to a

caloric * and *azotic air* for *oxygen,* attracts and fixes within itself *oxygen* †, (the *base* of oxygen air, for oxygen air is oxygen combined with a certain quantity of caloric:)...hence its *increase of weight,* and its *conversion into an oxyd or calx,* and hence the *azotic,* or *lethal, air left us* in the bell-glass....

That the temperature being increased‡, the affinity of the *caloric* for *oxygen* becoming now superior to the attraction of the *mercury,* the *oxygen* is withdrawn from the *oxyd of mercury* by the superior attraction of the *caloric*;... hence its *decrease in weight,* and its *restoration to fluidity and splendour,* and hence the produce of *oxygen,* or *vital, air*,...clearly displaying to us this important Truth;

That atmospheric air is actually a compound of two heavy substances, AZOT § *and* OXYGEN; ‖ *which bodies, when combined with* CALORIC, *or the matter of heat, are aeriform, and may be procured in separate states,* viz. *in the condition of* AZOTIC *and* VITAL AIRS, *which being mixed in a certain proportion,* viz. 3 *of the former to* 1 *of the latter, constitutes our* ATMOSPHERE.

a ftrong heat, the caloric expands this fluid; that is, insinuates itself through the body, and separates its particles (thermometers depend on this expansive power of fire), and, like the pieces of the bullet where sand interposed, the divided particles are no longer subject to the law of cohesion; then it is they obey the law of attraction, and each atom of mercury attracts to itself a particle of oxygen, just as a loadstone would draw to itself a particle of iron—The loadstone only attracts iron. This represents the term *affinity* in chemistry. The mercury did not attract the azot, because chemists would say it had no affinity for it.

* Fire, or the matter of heat.

† An experimentalist would illustrate this by placing a needle between two magnets of different powers. This would represent oxygen between the two attractions of the caloric and azotic air. As we may suppose a loadstone to have an attraction for the needle superior to the two magnets, so would it draw the needle to itself from these, just as the mercury draws away from the *azotic air* and *caloric* the *oxygen.*

‡ This is a curious fact; the temperature being increased, the *caloric alone* overcomes the elective attraction of *mercury* for *oxygen,* and depriving it of *that principle,* the *attraction of cohesion* takes place with the particles of *mercury,* and we obtain then *running mercury* and *oxygen gas.* To have recourse to the note * page 39, the *oxygen* and *mercury* being separated beyond their *sphere of attraction,* the *caloric* attracts to itself *oxygen,* just as either of the *magnets* (in the preceding note) would again attract to itself the *needle,* were it placed within its *sphere of attraction,* but *beyond that* of the *loadstone.*

§ That *azot* is a *solid substance* as well as *oxygen,* will be proved when we come to treat on manures. That the application of heat should render *oxygen* and *azot gaseous,* is not wonderful, fince we often observe *ice* by the admixture of *caloric* rendered a *fluid,* and heated to 212, converted into an aeriform and transparent gas. The hardest substance in the world, the *diamond,* may be volatalized in the same way. Mon. D'Arcet took a sphere of porcelain china, and after cutting it into halves, confined a *diamond* in the middle; he then joined the two sections ftrongly together. Putting these balls into a furnace, he afterwards unscrewed them, and found the diamonds evaporated, and the place which they occupied empty, though he could perceive no chink or fracture any where over the surface of the ball!

‖ The distinction betwixt air and vapour is this, both are formed of *particles* held in suspension by caloric, or heat, but by cold, or condensation, vapours return in time to their original form, whereas *airs* continue *permanently elastic.*

SECT. VIII.

III. THE COMPOSITION OF OXYGEN AIR.

When the hard STEEL combines with VITAL AIR,
And veils in *pearly clouds* the yielding fair,
Indignant FIRE the treacherous courtship flies,
Waves his light wings, and mingles with the skies.*

DARWIN.

THE ANALYSIS OF OXYGEN AIR;

Or its separation into its 3 CONSTITUENT PARTS, {1. OXYGEN, 2. CALORIC, and 3. LIGHT.

IN the slow calcination of metals, as in the former experiment with mercury, the disengagement of *light* and *heat* was too gradual to excite attention, and the fire of the furnace was confounded with it; hence we are indebted to Dr. Ingenhousz for a very beautiful experiment, clearly proving, that

OXYGEN AIR

Is composed of {1. OXYGEN, 2. CALORIC, and 3. LIGHT.

He took an *iron wire* (a watch-spring twisted in a spiral form exhibits this experiment best), and having fastened to one extremity a piece of *paper*, this

* In order to accommodate the verses of the poet to our subject, some alterations have been found necessary; but the reader will easily call to mind the original words, and, I trust, pass the eye of candour over this most difficult part of our labour.

he lights, and then thrusts the iron into a jar containing *vital air*, when the hot extremity immediately takes fire, and burns away rapidly, exhibiting a *dazzling light*, resembling the most brilliant fire-works,* a *white filmy smoke* is produced, and the iron, as it consumes, becoming saturated with oxygen, falls to the bottom of the glass in red-hot globules, which prove upon examination to be an æthiops, or oxyd of iron.

At the beginning of the combustion there is a slight augmentation in the volume of the air in the bell-glass, from the dilatation caused by the caloric or heat; but presently after a *rapid diminution* takes place, and *the mercury rises in the glass*, insomuch that when the *quantity of iron is sufficient*, and the *oxygen air operated on is very pure*, almost the *whole air employed* is *absorbed*;† or should the *quantity of iron be insufficient*, the *remaining air unabsorbed* will be found *perfectly pure vital air*.

The *theory* of this experiment is the same as the last.

At a certain temperature *iron* has a *stronger affinity* for the *oxygen* than *caloric* and *light* have.

It *therefore* attracts to itself the *oxygen*, and *caloric* and *light* becoming disengaged, are rendered *active* and *evident* to the senses.

* The rationale of fire-works are now no longer any difficulty. As *nitre* contains *vital air* in great abundance, from the combustion of different bodies, especially iron-filings, in *this air* arises so astonishing and pleasing a spectacle.

† That is, if 100 *grains* of *iron* be consumed in 70 *cubic inches of oxygen air*, the whole volume of air will disappear; and as 70 *cubic inches of oxygen air* weigh 35 grains, the 100 *grains of iron* will weigh, in its state of *æthiops*, *oxyd*, or *calx*, 135 *grains*.

SECT. IX.

IV. THE COMPOSITION OF WATER.

Nymphs! let your squadrons watch with chemic eyes
The fine elastic vapours, as they rise;
With playful force arrest them as they pass,
And to *pure air** betroth the *flaming gas*.†
Darwin.

Previous to our entering upon the subject of the effects of air on the vegetable œconomy, it will be necessary to shew, also, that *water*, though it be the solvent of a vast variety of bodies, is neither that *compound* or *simple element* formerly supposed, but made up of two *very distinct* and *different principles*.

The new and beautiful doctrine of the French chemist, respecting the composition of *air*, was daily gaining ground, and obtaining the applause of every one, when an experiment performed by Dr. Priestley made it for a while totter on its basis.

In the middle of a long glass tube this great experimentalist put some *calcined lead*, and affixed to the extremities *bladders* which were filled with *inflammable air*.‡ Having applied a strong heat to the middle of this tube,

* *Oxgen air.*

† *Inflammable air*, very improperly denominated so; for, the burning of all bodies is nothing more, as we saw in the last section, than the *decomposition* of *oxygen air*. It is the oxygen air, therefore, and not the combustible body, that gives out *light* and *heat*. When we are sailing on the water in a still day, *distinct objects appear to meet us*, but our reason corrects the delusion. When we behold the sun, moving from east to west, philosophy again assumes its empire, and we are convinced it is *stationary*. If we take a *prism*, it displays to us a variety of colours; our reason tells us here also, that *theſe colours* arise from the *rays of light*, and are not *in the prism*,—so of the combustion of bodies, the *caloric* and *light* are not from *the wax* of our candles, but from the *oxygen air*, which, as we see in many experiments, becomes, under certain circumstances, *decomposed*. Vide note (*), page (41).

‡ *This air* Dr. Prieſtley obtained from *diluted* vitriolic acid poured on iron. *Iron* was therefore said to contain a great quantity of *this air*. But the fact will soon appear that the air arose from the *decomposition of water* mixed with the vitriolic acid.

he next squeezed the bladders, and forced the *inflammable air* along the tube.

The *inflammable air* soon disappeared; no *oxygen gas* was evolved: but the *red lead* quickly *reassumed* its original metallic splendour.

A question then arose, whence *this property* in *inflammable air* which the *antiphlogistians* would ascribe to the evolution of *oxygen gas.**

The favourers of the new system were not able to deny the fact; and as the inflammable air, which was now called *phlogiston,* had in this experiment disappeared, they found some difficulty to persuade the supporters of the old doctrine that the revival of the metal could not be from the absorption of the inflammable air, as the red lead had lost a good deal of its weight, and the effect of an addition of matter (if inflammable air be matter) could be no other than to give it an increase of weight.

THE SYNTHESIS
OF
WATER;

Or its formation from its Two constituent parts, { 1. HYDROGEN, and 2. OXYGEN.

Fortunately for chemistry the Hon. Mr. Cavendish, by passing an electric spark through *oxygen air,* mixed with *inflammable air,* produced water.†

The reduction of the *red lead* in Dr. Priestley's experiment was then no longer a matter of surprise. At a *certain temperature* the *inflammable air* overcoming the attraction of the *lead* for *oxygen* divorced it of *that principle,* and uniting with it formed *water.*

* *Inflammable,* or *hydrogen air,* being 15 times lighter than common air, is employed for balloons. *Oxygen air* is even something heavier than common air. *Inflammable air* quickly destroys life, whereas *oxygen air* appears to be the very principle of life. *It* is considerably lighter than either *oxygen* or *common air. It* explodes when it comes into contact with *common air,* but more especially with *oxygen air,* provided any body in actual inflammation be present. The difference therefore between these two airs is very great.

† 35 grains, by weight, of *oxygen air,* and 15 grains of *inflammable* or *hydrogen air,* produced here precisely 100 grains of *water.* In this experiment *caloric* is disengaged, and the 85 parts of *oxygen* and 15 of *hydrogen* unite, which, being naturally *solid substances of themselves,* become, if nearly all the *caloric* be extracted from them, *ice*; if less, *water.*

THE ANALYSIS,

OR

Its separation into { 1. HYDROGEN AIR, and 2. OXYGEN AIR.

But that no doubt may be entertained on this head, I must beg leave to relate an experiment which was performed by Meusnier before a large assembly of the Academy of Sciences at Paris.

He took a *gun-barrel,* into which he put some thick pieces of *iron-wire* flattened by the hammer. He *weighed* the whole with a scrupulous exactness. He then *luted* the gun-barrel to secure it from the immediate contact of the fire. It was then placed in *a furnace,* but so *inclined* that water would easily glide down it.

He then adapted to the upper extremity a *funnel* containing water, from which it could not escape into the gun-barrel but drop by drop. This funnel was *closed at the top* to avoid any the least evaporation of the water.

At the lower extremity *vessels* were adapted to receive any aerial product. To use every precaution *these* were exhausted of their air.

The *gun-barrel* was now made red-hot, and the *water* from the funnel passed into it drop by drop. An astonishing quantity of *inflammable* or *hydrogen air** was quickly obtained.

Having removed the luting, the *gun-barrel* with its *contents* weighed considerably *heavier* than *before*; and *the acquired weight* of the gun-barrel being *added* to the *weight* of the *inflammable air* thus produced, was *precisely* the *weight* of the *water expended* in the process: and the *iron-wire* found in the barrel (the process being over) resembled in every respect *iron* that has been consumed in *oxygen air,* that is, it was become *martial æthiops,* which accounts for the *oxygen,* the other constituent principle of water.

* This *inflammable air* was generated from the *hydrogen* of the water, which united with the *caloric* of the furnace in its pasage through the barrel. *Inflammable air* the French chemists call *hydrogen gas,* from the Greek words *ὑδωρ water,* and *γεινομαι to beget.*

SECT. X.

V. THE COMPOSITION OF FIXED AIR.

Thus, by a length of years, and change of fate,
All things are light or heavy, small or great;
Hence Jordan's WAVES shall future *clouds* appear,
And Lebanon's tall CEDARS turn to *air*.

PRIOR.

SYNTHESIS

OF

CARBONIC ACID AIR, OR FIXED AIR;

Or the Union of its 2 CONSTITUENT PARTS, } 1. CHARCOAL, and 2. OXYGEN AIR.

As the composition of fixed air is easiest understood by Synthesis, we shall only mention, that if wood, or *Charcoal,* be burnt in *oxygen air,* it will be converted into an *acid gas,** whose *weight* will equal the sum of the *weights* of the *charcoal* which has been consumed, and the *oxygen air* employed.†

* The properties of *fixed air* are these; a candle or light is instantly extinguished in it, it soon destroys animal life, is heavier than either oxygen or common air, is quickly imbibed by water, giving to it the sparkling appearance, and taste, of Seltzer or Pyrmont water.

† From our experiment we find, that *fixed air* is composed of 28 *parts* of *charcoal* to 72 of *oxygen air*; or, in other words, 144 *cubic inches* of *that air* will saturate, or take up, 28 *grains* of *charcoal.*

SECT. XI.

VI. THE CONNEXION OF AIR WITH VEGETATION.

Go, gentle Gnomes! resume your vernal toil,
Seek my chill tribes, which sleep beneath the soil;
Oh, watch, where bosom'd in the teeming earth,
Green swells the germ, impatient for its birth;
Guard from rapacious worms its tender shoots,
And drive the mining beetle from its roots;
With ceaseless efforts rend the obdurat clay,
And bring my vegetable babes to day!—
See, from bright regions, borne on odorous gales,
The swallow, herald of the summer, sails;
Thou, whose soft voice calls forth the tender blooms,
Whose pencil paints them, and whose breath perfumes;
O chase the Fiend of Frost, with leaden mace,
Who seals in death-like sleep my hapless race;
Melt his hard heart, release his iron hand,
And give my seeds the power to expand.
Pervade the city dank, and heaving earths,
Where teeming Nature broods her myriad births;
Fill the fine lungs of all that *breathe* or *bud*,
Warm the new heart, and dye the gushing blood,
With life's first spark inspire the organic frame,
And, as it wastes, renew the subtle flame.

Darwin.

It is the Goddess who presides over Botany who is here supposed to address her attendant *Gnomes, Sylphs,* and *Zephyrs.* Her several addresses form the first part of the *Botanic Garden,* a poem which was intended to enlist the imagination under the banners of science, and to lead her votaries from the looser analogies, which dress out the imagery of poetry, to the stricter ones which form the reasonings of philosophy. The Goddess is thus invoked by the sublime Poet.

Winds of the North! restrain your icy gales,
Nor chill the bosom of these happy vales!
Hither, emerging from yon orient skies,
Botanic Goddess! bend thy radiant eyes;
O'er these soft scenes assume thy gentle reign,
Pomona, Ceres, Flora, in thy train;
O'er the still dawn thy placid smile effuse,
And with thy silver sandals print the dews;
In noon's bright blaze thy vermil vest unfold,
And wave thy emerald banner star'd with gold.

She comes!—the Goddess!—through the whispering air,
Bright as the morn, descends the blushing car;
Each circling wheel a wreath of flowers entwines,
And gem'd with flowers the silver harness shines;
The golden bits with flowery studs are deck'd,
And knots of flowers the crimson reins connect.
And now on earth the silver axle rings,
And the shell sinks upon its slender springs;
Light from her airy seat the Goddess bounds,
And steps celestial press the pansied grounds.—
And soon the Goddess, with attention sweet,
Turns to the *Gnomes*, who circle round her feet.

After the discovery of the air-pump by Boyle, it was natural to expect that experiments would be made with it upon plants, as well as animals. Accordingly we find in the first volumes of the Philosophical Transactions, published in 1665,*

"PROPOSALS"

" To try the Effects of the Pneumatic Engine exhausted, in Plants, Seeds, Eggs of Silkworms, &c."

" The noble Mr. Boyle suggests, as proper for the approaching spring, that it may be tried,"

* The idea of a literary society seems first to have originated with the great Lord Bacon, the father of modern philosophy, who recommended to the reigning prince to institute societies of learned men, who should give to the world from time to time a regular account of their researches and discoveries. It was the idea of this great philosopher, that the learned should be united, as it were, into one immense republic; which, though consisting of many detached states, should hold a strict union and preserve a mutual intelligence with each other, in every thing that regards the common interest. The want of this union and intelligence he laments as one of the chief obstacles to the advancement of science; and, justly considering the institution of public societies, in the different countries of Europe, under the auspices of the sovereign, to be the best remedy for that defect, he has given, in his fanciful work, the New Atalantis, the delineation of a philosophical society on the most extended plan, for the improvement of all arts and sciences; a work which, though written in the language, and tinctured with the colouring of romance, is full of the noblest philosophic views. The plan of Lord Bacon, which met with little attention from the age in which he lived, was destined to produce its effect in a period not very distant. The scheme of a philosophical college by Cowley is acknowledged to have had a powerful influence in procuring the establishment of the Royal Society of London by charter from Charles II.; and Cowley's plan is manifestly copied in almost all its parts from that in the New Atalantis.

At this period Mr. Boyle, Mr. Wren, Lord Brounker, Dr. Wallis, and other learned men, held meetings at Oxford, in which were received accounts of whatever was doing in the study of Nature; and many experiments were exhibited. The researches of Galileo, Toricelli, and Paschal, concerning

1. " Whether seeds, especially such as are of hasty growth, videlicet, orpin, lettice, garden-cress seeds, &c. will germinate and thrive in the exhausted receiver of an Air-Pump?"

the pressure of the air, greatly engaged their attention, and many additions were made to their discoveries. Mr. Boyle, the most ardent and successful studier of Nature, had the principal share in these improvements, his inquisitive mind being aided by an opulent fortune. In a letter to his nephew, Lord Dungarvon, he says, that he made many attempts to see the appearances exhibited by bodies freed from the pressure of the air. He had made Toricellian tubes, having a small vessel at top, into which he put some bodies before filling the tubes with mercury; so that when the tube was set upright, and the mercury run out, the bodies were *in vacuo.* He had also abstracted the water from a vessel, with a small pump, by means of a weight, having previously put bodies into the vessel along with the water. But all these ways were very troublesome and imperfect. He was delighted when he heard from Schottus's first publication, that Counsellor Guericke had effected this by the expansive power of the air; and immediately set about constructing a machine from his own ideas, no description of Guericke's being then published.

It consisted of a receiver, furnished with a stopcock and syringe, placed in a vertical position below the receiver. Its valve was in its bottom, close adjoining to the entry of the pipe of communication; and the hole by which the air issued was farther secured by a plug which could be removed. The piston was moved by a wheel and rackwork. The receiver of Guericke's pump was but ill adapted for any considerable variety of experiments; and accordingly very few were made in it. Mr. Boyle's receiver had a large opening, with a strong glass margin. To this was fitted a strong brass cap, pierced with a hole in its middle, to which was fitted a plug ground into it, and shaped like the key of a cock. The extremity of this key was furnished with a screw, to which could be affixed a hook, or a variety of pieces for supporting what was to be examined in the receiver, or for producing various motions within it, without admitting the air. This was farther guarded against by means of oil poured round the key, where it was retained by the hollow cup-like form of the cover. With all these precautions, however, Mr. Boyle ingenuously confesses, that it was but seldom, and with great difficulty, that he could produce an extreme degree of rarefaction; and it appears by Guericke's letter to Schottus, that in this respect the Magdeburgh machine had the advantage. But most of Boyle's very interesting experiments did not require this extreme rarefraction; and the variety of them, and their philosophic importance, compensated for this defect, and soon eclipsed the fame of the inventor to such a degree, that the state of air in the receiver was generally denominated the *vacuum Boyleanum,* and the air-pump was called *machina Boyleana.*

He was soon assisted by Dr. Hooke, the most ingenious and inventive mechanic that the world has ever seen. This person made a great improvement on the air-pump, by applying two springes, whose piston-rods were worked by the same wheel, and putting valves in the pistons, in the same manner as in the piston of a common pump. This evidently doubled the expedition of the pump's operation: and it also greatly diminished the labour of pumping; for it must be observed, that the piston must be drawn up against the pressure of the external air, and when the rarefaction is nearly perfect, this requires a force of nearly fifteen pounds for every inch of the area of the piston. Now when one piston is at the bottom of the barrel, the other is at the top of the barrel, and the air below is equally rare with that in the receiver. Therefore the pressure of the external air on each of the pistons is nearly equal. Both, therefore, are acting in opposite directions on the wheel which gave them motion; and the force necessary for raising the piston is only the difference between the elasticity of the air in the two barrels. This is very small in the beginning of the stroke, but gradually increases as the piston descends, and becomes equal to the whole excess of the air's pressure above the elasticity of the remaining air of the receiver when the air of the natural density begins to open the piston valves. An accurate attention to circumstances will shew us that the force requisite for working the pump is greatest at first, and gradually diminishes as the rarefraction advances; and when this is nearly complete, hardly any more force is required, than what is necessary for overcoming the friction of the pistons, except during the discharge of the air at the end of each stroke. This is then the form of the air-pump which is most generally used all over Europe. *Encycloped.*

2. " Whether the exclusion of air from the sensitive plant would be harmful to it?"

3. " Whether silkworms' eggs will be hatched in such an exhausted receiver, in the proper season."

" To which may be added,

4. " The trials of putting in a vial full of water, some of those herbs that will shoot and grow in water alone, including them in such a receiver, and pumping out what air you can, to see whether they will then shoot, or not?"

" And though some of these proposals have been formerly begun to be experimented, yet ought they to be diligently prosecuted, to see how far the air is necessary to vegetation; and whether plants do indeed live as much upon the air, as the earth; and the branches of them are rooted, as it were, in and quickened by the air, as their roots are planted and nourished in and by the earth."

" The experiment heretofore made of this kind was, that some lettice-seed being sown upon the earth in the open air; and some of the same seed at the same time upon another earth in a glass receiver of the abovementioned engine, afterwards exhausted of air; the seed exposed to the air was grown up an inch and a half higher, within eight days; but that in the exhausted receiver, not at all: and, air being again admitted into the said emptied receiver, to see whether any of the seeds would then come up, that in the space of one week they were grown up to the height of two or three inches."

The great Boerhaave, speaking on this subject, says, " That the eggs of every kind of insect, accurately inclosed in a small glass vessel, however exposed to the influence of the sun, do not come forth; and that plants committed to the ground, and the proper heat administered, if prevented from having access to the air, do not vegetate."

The celebrated Spalanzani, repeating the experiments of Boerhaave, found indeed that the eggs and seeds did not germinate, when confined in a very small quantity of air; and he endeavours to account for the *cause* of this *sterility*. " Mons. de Reaumur," says he, " took the crysalids of the cabbage caterpillar, and put them into glass tubes four or five inches long, which

were hermetically sealed: but they remained in their original state, although confined for several months, whereas other crysalids of the same kind were changed into butterflies."

"Under these circumstances there issues a noxious vapour from the crysalis, when in a confined place, and this reverting back on the subject, renders it *diseased*, and thus destroys it, as with animals confined in stagnant air."*

"The same thing," continues this naturalist, "happens to *seeds*. We know that they germinate only at a certain degree of heat, which occasions, an evaporation; and being confined in a small vessel, they in consequence reabsorb the exhalations which they had before transpired, and then become corrupt. Upon taking out seeds which had been so exposed, I have often found the surface covered by a humid pellicle."

If this great naturalist had carried his trials but a step further, he would have found that his seeds would have vegetated, and that the exclusion of the air alone had hindered the expansion of the living principle.

Hence it is, upon digging deep in the ground, plants have often been known to appear, not before observed in that district for time immemorial.

Morrison observes, "That after the late prodigious conflagration of the city (namely, the fire of London in 1665), the ruins being dug up, there grew spontaneously the Sisymbrium Irio *(Broad-leaved Hedge Mustard)*, a rare plant in those parts, but now so abundant, as to exceed the produce of all Europe besides."

Two years ago a crop of wild mustard was reaped from the banks raised at Hull to form a dock for the reception of shipping; and it has been often noticed, that a spontaneous crop of this vegetable makes its appearance, for two successive years, upon the banks of all drains made in Holderness.

"Similar appearances," says Dr. Hunter, "have been observed in the isle of Oxholme, and other low countries."

"The Lobelia *(Cardinal Flower)*," says Linnæus, "six years ago, suddenly reappeared in the Physical Gardens at Amsterdam, which had been lost there upwards of twenty years."

* The error of this supposition has been successfully refuted by modern philosophers; for since the discovery of the composition of the atmosphere, and its separation into oxygen, and azotic, airs, it has been found after animals have died in a vessel with a given quantity of air, without removing the supposed noxious effluvia, oxygen air being added to the vessel, animals have then lived as freely, or even better, than in common air.

"And the Hypecoum Procumbens *(Procumbent Hypecoum),* which had been lost in the garden of Upsal since the time of Rudbeck the father, also appeared as they were breaking up the earth in a particular part, the seeds having laid dormant there upwards of forty years."

Hence we may conclude that, independent of heat and moisture, another requisite is necessary towards the first growth of seeds, namely, *air.*

But what will clear up this subject best are direct experiments made with the view to ascertain this curious point.

EXPERIMENT I.

December 2d, 1796, a quantity of barley, after having been soaked in water twenty-four hours, was put into a wine glass, and introduced under a jar containing *common air,* which was afterwards inverted over water to prevent the escape of air,

It may be necessary to remark, that the temperature in this, as well as the other experiments about to be related, was from sixty to seventy degrees, as nearly as possible.

At the expiration of five days they began to vegetate, and at the end of twenty-eight days the plume had shot out half an inch in length.

On February 7th, vegetation was still going on, and the air in the jar was *diminished,* and the barley being withdrawn was found to be very sweet, and converted nearly into the state of malt.

The air of the jar was now examined, and found to consist of

1. *Azotic,* and,
2. *Carbonic acid gas,* or fixed air,

in the proportion of twenty of the former to six of the latter; so that the whole of the *oxygen gas* must have been either absorbed, by the vegetable, or converted into carbonic acid gas.

EXPERIMENT II.

June 19th, 1797, a quantity of barley, treated as in the last experiment, was introduced into a jar containing, instead of common air, the pure *oxygen air.*

At the end of *three* days only it began to grow, and this process went on favourably to the 29th.

The water had now risen considerably in the jar, and the gas had suffered a diminution of one third.

The barley being now withdrawn smelled completely maltish, and tasted sweet.

The gas in the jar, upon examination, proved to be,

1. *Carbonic acid gas*, or fixed air,
2. *Oxygen gas*;

in the proportion of sixty-four parts of the former to four of the latter.

EXPERIMENT III.

January 23d, a quantity of barley, soaked in water for two days, was introduced into a jar containing only forty-six measures of pure *oxygen gas*.

At the end of *three* days the barley began to grow, but soon after the vegetation ceased, and the column of air underwent no apparent diminution; when the air in the jar was examined, it was found to be,

1. *Carbonic acid air*,
2. *Oxygen air*;

of the last not one part even out of the forty-six remained, and the barley was only partly converted into malt, the quantity of *oxygen gas* being insufficient to influence the whole.

EXPERIMENT IV.

Another experiment with *common air* was made at the same time, and exactly under similar circumstances.

In this case the barley did not begin to vegetate until the *end* of the

* The indulgent reader will please to run his pen over an error of the press in the last page, which should have been 52 instead of 40; or, the sense will readily enough obviate any inconvenience from this accidental oversight.

fourth day; and at the period of investigation, which was the same as the last, had made much less progress than in the oxygen gas.

The air in the jar being examined, it was found to contain,

1. *Azotic gas,*
2. *Carbonic acid gas*;

nearly in the proportion of one to two, mixed with a small quantity of oxygen gas, and but little of the barley tasted sweet.

Being now satisfied that, during the evolution of the saccharine principle from vegetable mucilage, a quantity of oxygen was either absorbed or converted into carbonic acid, we wished to know if this process could take place in any degree without the presence of this gas.

In order to determine this point, the following experiments were made.

EXPERIMENT V.

January 20th, a quantity of barley, soaked as in the former experiments, was introduced into a jar filled with and inverted over *mercury.*

At the expiration of 12 days a very considerable quantity of gas was produced, at least five or six times the bulk of the barley; but *nothing like vegetation was perceived.*

The gas, on examination, was found to consist of *carbonic acid,* being entirely absorbed by lime-water.

The barley had not the *least sweet taste,* nor did it appear to have undergone any sensible change.

EXPERIMENT VI.

On January 20th, another portion of the same soaked barley was introduced into a wine glass, and placed in a jar containing *nitrous gas,** inverted over water.

At the expiration of 10 days the gas had undergone a slight diminution, but there was not the smallest appearance of vegetation.

The barley being withdrawn and examined, was found to have undergone no apparent change.

* An account of the nature and formation of nitrous gas is given in note * page 56.

The gas contained about 1-9th of its bulk of carbonic acid, the remainder being pure nitrous gas, as was manifest from the diminution it underwent when mixed with pure air.

The nitrous gas which disappeared in this instance must have been absorbed either by the barley or the water; the carbonic acid which was found mixed with it, is accounted for by the last experiment.

EXPERIMENT VII. AND VIII.

Two other portions of soaked barley were introduced into jars, the one containing *hydrogenous,** and the other *azotic gas,* and these were inverted over mercury.

At the expiration of 12 or 14 days there was not the least appearance of vegetation in either, but the gas in both had increased in bulk about 1-5th. The barley being withdrawn and examined, that in the hydrogenous gas tasted musty, but not in the *least sweet*; the portion in the azote appeared to have undergone no change.

The gas in both jars contained from 1-3d to 1-4th of its bulk of *carbonic acid,* the remainder being the original gases not sensibly changed.

CONCLUSION FROM THESE EXPERIMENTS.

From these experiments, therefore, it is manifest that *oxygen* is absolutely necessary for the conversion of vegetable mucilage into sugar, the food of the embryo; as in no one instance was saccharine matter formed where this was not present, and the quantity of the former was always in proportion to that of the latter; for we found in all our experiments, that when the oxygen was consumed this process immediately ceased, and that its quickness was in proportion to the oxygen present.†

In the year 1789 the late Dr. INGENHOUSZ made the following experiments, with a view to ascertain *what species,* or *mixture of airs,* was *most favourable* to the *growth of seeds.*

* For the nature and production of hydrogen gas see note * page 56.

† The above-related experiments were made by my very ingenious friend Mr. CRUICKSHANK, chemist to the Ordnance.

December 1st this great experimental philosopher put into the window of his chamber several islands made of cork, cut into the shape of a crown, and covered with blotting-paper floating in water, on which were sown *cress-seed.* The heat of the room was 13 degrees of Reaumur.

EXPERIMENT IX.

One of these floating islands was placed under a glass bell containing twelve cubic inches of *inflammable air* (HYDROGEN AIR), extracted " from *iron*," by adding to it the vitriolic acid.*

EXPERIMENT X.

A second was enclosed in *air corrupted by breathing.*†

* *Inflammable air* was the discovery of Dr. Priestley. He poured the *diluted* vitriolic acid upon iron filings, or nails, and immediately a dissolution of the iron took place, bubbles of air were engendered, and these being caught, were found to have peculiar characteristic marks. An animal being placed in this air died convulsed, a candle became extinct, and being found 15 times lighter than atmospheric air, it was soon employed in the formation of *balloons,* which in this age has, alas! realized the fable Icarus.

Where were ye, SYLPHS? when on the ethereal main
Young *Rosiere* launch'd, and call'd your aid in vain?
Fair mounts the light balloon, by Zephyr driven,
Parts the thin clouds, and sails along the heaven;
Higher and yet higher the expanding bubble flies,
Lights with quick flash, and bursts amid the skies.—
Headlong HE rushes through the affrighted air
With limbs distorted, and dishevel'd hair,
Whirls round and round, the flying crowd alarms,
And death receives him in his sable arms!

DARWIN.

This air is called *inflammable,* although *per se,* it extinguishes flame, from this circumstance alone, that, when lighted, it burns when in contact with common air, and mixed with a proportion of oxygen, so rapid is the combustion, that it takes fire at once, and explodes with a noise resembling a cannon. Some *inflammable air* blown under soap-suds, a lighted bougie being applied to them, makes so loud a noise, that it seems absolutely to crack, as the common phrase is, the very drum of the ear.—The reader has before learnt, that *light* and *heat* alone proceed from *oxygen air.* In the mode above related of procuring this air, it neither proceeds from the " *iron,*" or the vitriolic acid, but from the *water* which has been added to the last; for no air can, in fact, be produced from concentrated vitriolic acid poured upon iron. The theory of this experiment then is as follows. VITRIOLIC ACID is *sulphur* and *oxygen.* IRON is a simple or uncompounded body. WATER is a compound of *hydrogen* and *oxygen.* Now, when these are mixed, the *oxygen* of the vitriolic acid and of the water, having a greater affinity for the iron than for the sulphur or the hydrogen, deserts both these, and unites with the iron; and the *hydrogen* being liberated and rarefied by the *caloric* produced in this experiment, hence it assumes an aerial form, or the condition of *hydrogen air.*

† This was a mixture of azotic air and fixed air, with a small proportion of atmospheric air; for

EXPERIMENT XI.

A third was surrounded by *hydrogen air,* to which was added a portion of *oxygen air.*

EXPERIMENT XII.

A fourth was in *hydrogen air,* to which was added only a portion of *common atmospheric air.*

EXPERIMENT XIII. AND XIV.

The same thing was done by the *air corrupted by breathing* as in the two last experiments.

EXPERIMENT XV.

A seventh was placed in *common air.*

EXPERIMENT XVI.

And the last was in *oxygen air* of 300* degrees of purity.

the air passing over the ramification of the blood-vessels in the lungs is decomposed. Oxygen air is absorbed by the blood, and at each expiration there is fixed air thrown out with water, and the residuary azot, which acts chiefly as a vehicle or alloy to the oxygen air, which now passes into the blood.

* The degree of goodness of any air is ascertained by means of an instrument called an EUDIOMETER, the invention of Dr. Priestley, which is a long glass tube graduated, containing the air you wish to examine. This is inverted over water, and examined by the means of *nitrous air.* This air was the fortunate discovery of Dr. Priestley, who produced it by pouring the nitrous acid on copper or any other metal, when a dissolution of the metal takes place, and the oxygen of the nitrous acid, uniting with the metal to which it has a greater affinity than for its own base, calcines it, leaving the nitrous air free, which ascends in its aerial form. Now this air, when it meets with oxygen air, from the law of affinity, to which it is subject, quickly unites with it, and is reconverted into the state of nitrous acid. This is, says Dr. Priestley, one of the most astonishing experiments in chemistry. When you pour vitriolic acid on marble you are surprised to find torrents of fixed air issue from the solid body. Here you see two airs occupying considerable bulk, when coming into contact, instead of being as before diaphanous, now assume a red colour, and seize upon and devour each other in such a way, that they soon occupy an inconsiderable space; and one measure of this air will destroy four of oxygen, when it becomes nitrous acid, which is absorbed by the water as it rises up the tube. Nitrous acid attacks no other air than oxygen air, because it has no affinity for any other than this; and hence it discovers the quantity of oxygen air in any given volume of air, and thus becomes the test of the purity of any air which we know to depend upon the quantity of oxygen air it contains.

EXAMINATION OF THE SEEDS.

I. December 20th, The seeds in *inflammable air* were only a little swollen, but did not vegetate.

II. Those enclosed by *air corrupted by breathing* vegetated; but on the 15th of December the plants were of a yellow colour, and had perished before the 20th.

III. When *oxygen air,* or *common air,* were added either to the *inflammable air* or the *air corrupted by breathing,* the seeds grew and flourished in exact proportion to the quantity and purity of the added air. But if only a small portion of either airs were added the plants soon perished.

IV. The seeds in *common air* grew in the ordinary way.

V. But those, on the contrary, surrounded by the *oxygen air* rose the first, appeared uncommonly vigorous, and were much finer and greener plants than any of the others.

EXAMINATION OF THE AIR.

I. No alteration was found in the *inflammable air.*

II. The *respired air* was reduced from 12 to 10½ cubic inches, one inch of which was *fixed air,* and the remainder *azotic.*

III. In Experiments XI. XII. XIII. and XIV. the *oxygen air* had wholly disappeared, and we had remaining the *mephitic airs* in their genuine state.

IV. There remained from Experiment XV. with the *atmospheric air,* 11 cubic inches, one inch of which was found to be *fixed air,* and the remainder *azotic.*

V. In none of these experiments was there a vestige of *oxygen air,* this being partly *absorbed* by the plant, and partly *converted* into *fixed air.*

VI. From the experiment with the *oxygen air* there remained 10 cubic inches; 2 cubic inches were therefore *absorbed,* 3 were converted into *fixed air,* and the residue was *oxygen air,* but reduced to 160 degrees of goodness.

CONCLUSION FROM THESE EXPERIMENTS.

Hence, says Dr. Ingenhousz, we are warranted in this conclusion,

I. That *atmospheric air* is useful to vegetation *only* on account of the *oxygen air* which it contains. And,

II. That the *mephitic airs* are adverse to growth only as not containing in their composition *oxygen air.*

III. That *oxygen air* is not only favourable to the growth of plants, but also still more so than atmospheric air.

IV. That *oxygen air* is the true pabulum of vegetable, as of animal, life.

SECT. XII.

VII. WHETHER OXYGEN IS SUPPLIED TO SEEDS THROUGH ANY OTHER MEDIUM THAN WATER PERCOLATING THE EARTH?

To thy lov'd theme return, my happy muse,
For now, behold, the joyous winter-days
Frosty, succeed; and through the blue serene,
For sight too fine, th' *ethereal nitre* flies;
Killing infectious damps, and the *spent air*
Storing afresh with elemental life....
'Tis *the air* that *feeds* and *animates* our *blood.*
All NATURE feels the *renovating* force
Of winter, only to the thoughtless eye
In ruin seen. The frost-concocted glebe
Draws in abundant vegetable soul,
And gathers vigour for the coming year.

THOMSON.

THE poet, from whose immortal work on the Seasons I have selected my motto, approaches so near to what are styled the *new doctrines* relative to the influence of the atmosphere on the blood,* and even on the earth, that I should have been almost inclined to think he had derived his notions from MAYOW, the philosopher of the last century, unless they had differed as to the season when this sublime process of Nature is chiefly carried on.

Mayow had taught, that the earth became fruitful from the absorption of nitro-aerial particles, and founds his opinion on the following observations.

" Among the PRINCIPLES of natural things, the *nitro-aerial particles* (which is one of the component parts of nitre,† derived to it from the air)

* Vide the PHILOSOPHY OF MEDICINE, or, Medical Extracts on the Nature of Health and Disease; including the Laws of the Animal Economy, and the Doctrines of *Pneumatic Medicine*, by the Author of this work, in five thick volumes octavo.

† It has been computed by the Abbé FONTANA, that a pound of *nitre*, calcined in a close vessel, yields 12,000 cubic inches of OXYGEN, or VITAL, AIR. It is singularly curious that a substance of such very humble pretensions as common *nitre* (salt-petre) should possess properties on which hangs the fate of the most powerful empires! Since by chemistry it may either be converted into a fulmi-

hold a preeminent rank, and may justly be styled, *Mercury,* as being a substance the most subtle, agile, ethereal, and the prime instrument of vegetable as of animal life."

"The Peripateticks reckoned two principal elements, namely, *fire* and *air*; for both of which our *nitro-aerial Mercury* may be substituted, as possessing the nature of fire itself, and constituting, moreover, the most active and fermentative part of the air."

"With respect to a second element, namely, the *spirit* of certain chemical writers, I am unable to comprehend what they designate by this being, whom they place as the leader of their band of elements, and call an *exalted spirit,* unless it mean the same as that which results from the fermentation of liquor, which rapidly takes fire, when any lighted body is presented to it, and which I think it better to express by the term *sulphur.*"

"Thirdly, those saline and corrosive parts which remain after the combustion of plants: these more properly come under the denomination of *salts.*"

"Besides these, we have, fourthly, *water*; and, fifthly, *earth.*"

"Of these the *nitro-aerial particles* alone deserve the appellation of *spirit.*"

"The *sulphur* is the next in activity to the nitro-aerial particles, with whom it has a perpetual contest."

"The *salts* possess a passive nature, but are more nearly allied to the nitro-aerial spirit than the sulphur."

"The *water* acts only as a vehicle of the salts and sulphur;"

"And the *earth* gives a proper consistency to the whole."

"Having premised thus much, we come now to the play of these elements."

"At the commencement of spring, the *nitro-aerial Mercury,* from its keen, active, and penetrating nature, and the attractions which invite him, *descends deep into the earth,* and assails in the first place the *sulphur,* which is now firmly combined with the *salts,* and, as it were, entirely engaged in the embraces thereof."

nating engine, to overturn fortified cities, and to enable the garrison to launch out death and destruction on the besiegers: Or,... that by a different process, it may be made to pour forth VITAL AIR, that VIVIFYING FLUID diffused through the atmosphere, which breathes in the zephyrs, which whispers in the breeze, and which cheers and supports all animated Nature!... Dr. FOTHERGILL.

"The conflict now becomes terrible, and, from the mutual impulses given by each, is stirred up that remarkable effervescence, productive of a certain degree of *mild heat,* by means of which the common mother cherishes, with a vital warmth, the seeds committed to her bosom."

"The *salt,* spectatress of the contest, remains, like a timid mistress, passive, and detached from the embraces of her former lord, now chooses the conqueror, and this new intercourse forms either an *acid* or *nitre*; and the vanquished sulphur, freed from the shackles of the salt and earth, assumes a volatile nature."

"This state of things appears to me," continues Mayow, "exactly suited to vegetation: and we find actually, that, under these circumstances, plants take their greatest increase, and nitre is chiefly produced; and this occurs especially in the *spring season.* For in the winter the nitro-aerial particles, the salts, and sulphur, are bound by ice, as in adamantine chains, and are then incapable of any motion, and vegetables cease to grow."

"From this doctrine we see why the excrements of animals, as also lixivial salts, and even quick-lime, render the earth fruitful."

"For the salino-sulphureous excrements of animals are particularly useful, as effervescing with the nitro-aerial spirit, thereby giving a due warmth to the earth for the cherishing of seeds, when the sulphur becoming liberated, and the salt combining with the nitro-aerial spirit, nitre is generated, which conduces not a little towards the growth of plants."

"This is proved, likewise, by the analysis of vegetable bodies, which contain an *inflammable body* (sulphur) volatile; a *saline body* (an alkali) fixed, not to be dispersed by the greatest heat of the crucible; *water* readily dissipated; and a *nitre* seen by the combustion of plants, many burning with a flame although green, especially the beech, which burns with a bright blaze, and with a crackling noise, the very characteristic of deflagrating nitre."

Evelyn, in his "*Terra, or, A Philosophical Discourse on the Earth, and the Culture and Improvement of it for Vegetation,*" which was read before the Royal Society in the year 1675, the year after Mayow had published his five treatises,* which have made so great a noise in the present

* Tractatus quinque medico-physici, quorum primus agit de Sal-nitro, et Spiritu Nitro-aereo, secundus de Respiratione, tertius de Respiratione fœtus in utero, et ovo, quartus de Motu Musculari, et spiritibus animalibus, ultimus de Richitide, Studio Joh. Mayow, LL.D. et Medici, necnon Coll. Omn. Anim. in Univ. Oxon. Socii. An. Dom. 1674.

The learned Dr. Beddoes, lecturer on chemistry at Oxford, was the first who held up the merits

day, says, when discoursing "on the advantage of *fallowing*, of which Virgil speaks so highly,"

> "Illa seges demum votis respondet avari
> Agricolæ, bis quæ solem, bis frigora sensit
> Illius immensæ ruperunt horrea messes."
>
> GEORG. II.

> "That crop rewards the greedy peasant's pains
> Which twice the sun, and twice the cold, sustains,
> And bursts the crowded barns with more than promised gains!"

---

of Mayow to the literary world. The analysis which he gave was, however, very hastily performed. His other important avocations hurried him too much in detailing "the opinions of the philosopher of the last century;" and, in a public letter to Dr. Yeats, he candidly acknowledges that this work was written in too cursory a manner. Dr. Scherer, of Vienna, and De la Metherie in France, next attempted to enlighten their country respecting the merits of Mayow. Dr. Yeats, of Hertford College, Oxford, afterwards wished to give the public a fuller account of this extraordinary man. A work was undertaken by him for that purpose, entitled, "Observations on the Claims of the Moderns to some late Discoveries in Chemistry and Physiology," to shew how far the recent discoveries in these branches of science were entitled to Novelty. "I have long," says this gentleman, "accustomed myself to, and been peculiarly delighted with, reading the works of the last century; an age distinguished for the productions of many learned men in every department of science. Little did I imagine, at first, that such employment would be the subject of publication; and as little did I conceive, that I should trace out facts supposed to be but very recently discovered. I could not be surprised, too, when I observed theories, founded upon these facts, very similar to those we now entertain. I mentioned them, during conversation, in the philosophical circles which I had the pleasure to attend during my residence in London. Some believed, more disbelieved, and many supposed, that from the glow of conversation, exaggeration might creep in. Having collected a sufficient number of proofs to justify my observations, I imagined they would afford an hour of entertainment to the curious reader."

"It is a source, too, of rational and agreeable amusement to the cultivated mind to examine the similarity of opinions, in distant periods, and to trace the progress of science. It is curious to observe the co-incidence that sometimes takes place between the philosophical systems of great men. As researches into nature ever afford a pleasing employment to rational minds, and as her operations are all directed by fixed and immutable laws, it is not inconsistent to expect, that even in periods the most distant from each other, the philosophical pursuits of the literary will converge to the same point. The same observations, with respect to facts, have, no doubt, repeatedly occurred to every inquirer; and results, which arise from the consideration of general principles, have presented themselves, in a similar point of view, to the examination of philosophers. But it is not a loose *hint* thrown out, nor a system founded upon *conjectural* philosophy, that entitles a man to the merit of a *discoverer*. An arrangement of facts, the result of experimental inquiry and close reasoning alone, claims that honourable appellation. Laborious, indeed, is the investigation which requires it, and tedious the course. How carefully, therefore, ought we to avoid wresting from the brow of a *discoverer* the dear-bought crown of literary fame. It affords a grateful pleasure to a feeling mind to observe each man possessing the rewards due to his labours, and, however difficult it is, to award the *suum cuique*; yet investigation, under almost every circumstance, contributes to that end, and promotes the dispensation of distributive justice."

Coinciding perfectly with Dr. Yeats in this just sentiment, yet I cannot help differing from him in the opinion he entertains for MAYOW, who appears to me, judged by this canon, rather to have *approximated* to the truth by the sagacity of a penetrating genius, than actually to have *discovered* it. I fear, likewise, he borrowed much from HOOK, which will be shewn hereafter.

" There are, I confess, who fancy that this long exposure of earth, before it come into employ, causes it to exhale the little virtue it already possessed; but, provided nothing be suffered to grow on it whilst it lies fallow, there is no danger of this, for, in fact, *no compost* or *lætation* whatever is comparable to the influences of the heavens, which does, in a great measure, fertilize the earth alone. For, verily, it is almost a miracle to see how the same land, without any other manure or culture, which before was almost effete, will bring forth and even luxuriate, and that by the bare raking and combing of the earth, now one way, and then another, as to the regions of heaven and polar aspects, which is indeed a secret worthy to be considered."

" Take," says he, " the most barren earth you can find, drained, if you please, of all its nitrous salts and masculine parts; reduce it to a fine powder (which may be done even in large proportions, by a rude engine, letting fall a kind of hammer or beetle at the motion of a wheel); let this pulverised earth, which may be frequently agitated, be exposed for a summer and winter to the vicissitudes and changes of the seasons, and influences of the heavens; by this labour, and rest from vegetation, you will find it to have obtained such a generous and masculine pregnancy within that period as to make good your highest expectation; for the earth has a certain *magnetism* in it, by which it attracts the salt, power, or virtue, call it what you please, which gives it life, and is explanatory of the reason of the ploughing, digging, and the advantages arising from incessant labour, confirming the old proverb,"

" Annus fructificat non tellus;"

" for the earth, when once impregnated with the influences of the heavens, becomes so fitted for vegetation, that it receives the seeds committed to its bosom with a passion and fervency, as it were, of animal love."

Sir Kenelm Digby, in his discourse on *Sympathetic Powders*, affirms, " that the earth, in the years of repose, recovers its vigour by the attraction of the vital spirits which it receives from the air, and those superior irradiations which endow simple earth with qualities productive of fermentation."

To this belongs Sir Hugh Platt's contrition, or philosophical sifting of earth, " which, by this process alone, without manure of soil, will in time create a rich, mellow earth, fitted to receive every plant, even from the farthest Indies, and cause all vegetables to prosper in a most exalted degree," and, to speak as magnificently as the illustrious author, " occasion them to

thrive as kindly with us as in their natural climate;" and this Dr. Bunting affirms to have himself accomplished."

"That by the air," continues Evelyn, "the moist effete and elixiviated mould comes to be repaired, and is qualified to attract the prolific nitrous spirit (which converts her inactive salts into quite another genius and nature, and, invading the sulphur, stirs up an intestine fermentation, which gives life, and growth, and motion, to all she produces), the learned Dr. Mayow has very ingeniously made out; and all this by a naked exposure of the earth to the air alone, without which it produces nothing."

"Nor can plants, totally excluded from the air, live, or so much as erect themselves to any thriving purpose, as being deprived of that breath and vital balm which no less contributes to their *growth* and nourishment, than does the earth itself with all our foreign assistances."

We cannot help here remarking, that although we must admire the sagacity of our ancestors, who thus, by mere observation of natural phenomena, wonderfully approached those truths which the most accurate experimental analysis has at this day demonstrated, yet must we confess, that the merit of actual *discovery* is more properly due to philosophers of the present times; for it is one thing to *conjecture,* and a very different to *demonstrate.*

The honour, therefore, of really proving the *fecundating property* of vital air, *as absorbed by the earth,* is due to my worthy and much-lamented friend Dr. Ingenhousz.

EXPERIMENT I.

"I put," says this philosopher, "under a bell, containing forty-six cubic inches of common air, some garden mould, and I exposed this, in a suitable apparatus, from six at night to the same hour the next day, and I found the air *reduced* below 12 degrees of the quality of common air."

EXPERIMENT II.

"At nine o'clock in the morning I put under a bell-glass, containing 100 inches of common air, four plants of the mint kind, very vigorous, and growing in a pot filled with garden-mould, and, examining the air at six in the evening, I found it *degraded* from 99 to 93 degrees."

EXPERIMENT III.

" But if the earth, instead of being mould, is a quartous sand well washed, no such corruption was observed to take place."

EXPERIMENT IV.

" This same plant, being divested of all earth adhering to its roots, enclosed for the same period in atmospheric air, instead of diminishing its oxygen, was found to have increased it to a very considerable degree."

CONCLUSION.

Hence we may conclude, that the surrounding atmosphere is continually decomposed by the earth, and that the VITAL AIR imbibed into it is one of the chief agents of Nature in the process of vegetation.

SECT. XIII.

VIII. ON THE FERTILIZING POWER OF SNOW.

Oh! may'ſt thou often see
Thy furrows whitened by the woolly rain;
Nutritious, secret NITRE lurks within
The porous wet, quick'ning the languid glebe.

PHILIPS.

In the new, or French Calendar you find the months Brumaire (our November), Frimaire (December), Nivose (January), Pluviose (February), and Ventose* (March), succeed each other, all converging to one point, namely, the *oxygenation* of the land, as we shall endeavour to prove.

---

*THE FRENCH CALENDAR.

Vendemaire, the *Vintage*, 1ſt. answering to our	September 22, to
Brumaire, *Fog* - - - - - -	October 22, to
Frimaire, 1. *Frost* - - - -	November 21, to
Nivose, 1. *Snow* - - - - - -	December 21, to
Pluviose, *Rain* - - - - - -	January 20, to
Ventose, 1. *Wind* - - - - - -	February 19, to
Germinal, 1. *Budding* - - - - -	March 21, to
Floreal, 1. *Flowers* - - - -	April 20, to
Prairial, *Hay-harvest* - - - - -	May 20, to
Messidor, *Corn-harvest* - - -	June 19, to
Thermidor, *Intense Heat* - - -	July 19, to
Fructidor, *Fruit* - - - - - -	Auguſt 18, to September 22.

A NEW ENGLISH CALENDAR.

The Months of our Calendar might be thus expressed.

I. The *Foggy* Month, NOVEMBER.

Lord, how thy wonders are display'd,
Where'er I turn mine eye!
If I survey the ground I tread,
Or gaze upon the sky!

There's not a plant or flow'r below,
But makes thy glories known;
And *clouds* arise, and tempeſts blow,
By order from thy throne.

We shall not now particularly consider, how the earth is moistened by the dews of our November, and thus the rains sink deep and remain in the earth;

II. *Frosty* Month, December.

Oh *Winter!* ruler of th' inverted year,
Thy scatter'd hair is with frost like ashes fill'd,
Thy breath congeal'd upon thy lips, thy cheeks
Fring'd with a beard made white with other snows
Than those of age; thy forehead wrapt in clouds;
A leafless branch thy sceptre; and thy throne
A sliding car indebted to no wheels,
But urg'd by storms along its slipp'ry way.

III. *Snowy* Month, January.

In winter awful thou! with clouds and ftorms
Around thee thrown, tempest o'er tempest rolls
Majestic darkness! On the whirlwind's wing
Riding sublime thou bidst the world adore,
And humblest nature with thy *northern blast*.

IV. *Thawing* Month, February.

Reviving nature seems again to breathe,
As loosen'd from the cold embrace of death.

V. *Windy* Month, March.

.............For conflict dreadful!
The West encounters East, and Notus meets
In his career the Hyperborean blast.
The lordly lions shuddering seek their dens,
And fly like timorous deer; the king of birds,
Who dar'd the solar ray, is weak of wing,
And faints, and falls, and dies; while HE supreme
Stands stedfast in the centre of the *storm*.

VI. *Showery* Month, April.

How fine has the day been, how bright was the sun,
How lovely and joyful the course that he run,
Though he rose in a mist when his race he begun,
And there follow'd some *droppings of rain!*

VII. *Budding* Month, May.

........Forth in the pleasing *spring*
Thy beauty walks, thy tenderness and love.
Wide flush the fields; the soft'ning air is balm;
Echo the mountains round; the forest smiles;
And every sense, and every heart, is joy.

VIII. *Flowering* Month, June.

All that is *sweet* to smell, all that charm
Or eye or ear, bursts forth on every side,
And crowds upon the senses.

and how afterwards the frost succeeds in December, and turns this water into ice, which would destroy, in great measure, the seeds and plants in the bowels of the earth, unless Nature had, in the same or following month, kindly

---

This might be also called the *mowing* Month.

When the fresh spring in all her state is crown'd,
And high luxuriant grass o'erspreads the ground,
The labourer with a bending scythe is seen
Throwing the surface of the waving green;
Of all her native pride disrobes the land,
And meads lays waste before his sweeping hand;
While with the mountain sun the meadow glows,
And fading herbage round he loosely throws,
Then next into his hands the fork he takes,
And ruddy damsels ply their wooden rakes.

IX. *Ripening* Month, July.

Berries and pulpous fruits of various kinds,
The promise of the blooming spring, now *yield*
Their rich and wholesome juices, meant t' allay
The ferment of the bilious blood.

X. *Reaping* Month, August.

Pour'd from the villages, a numerous train
Now spreads o'er all the fields. In form'd array
The *reapers* move, nor shrink from heat or toil,
By emulation urg'd. Others dispers'd,
Or bind in sheaves, or load or guide the wain
That tinkles as it passes. Far behind
Old age and infancy with careful hand
Pick up each straggling ear.

XI. *Sowing* Month, September.

Arise, ye winds, 'tis now your time to blow,
And aid the work of Nature. On your wings
The *pregnant seeds* convey'd shall plant a race
Far from their native soil.

XII. *Shedding* Month, October.

How sweetly Nature strikes the ravish'd eye
Thro' the fine veil with which she oft conceals
Her charms in part, as conscious of *decay*.

Mysterious round! what skill, what force divine,
Deep-felt in these appear! a simple train,
Yet so delightful mix'd, with such kind art,
Such beauty and beneficence combin'd;

thrown over them a fleecy mantle, which serves as a *defence* against the piercing cold, snow being a bad conductor of heat. For the earth has always produced from the jar of its elements an internal heat, whose temperature at a sufficient depth is found to be equal to 48 of Fahrenheit's thermometer.

Hence a continual contest between the heat of the earth and the snow, the result of which is carrying the temperature to the intermediate point between this and the freezing point.

The object, however, of the present section is to prove that *ice,* or what is the same, *snow,* has its fertilizing power from its possessing a superabundance of *oxygen,* which it imparts to the earth.

Dr. Grew, in his discourse on the nature of snow observes, " that many parts thereof are of a regular figure, for the most part, being, as it were, so many little stars of perfect ice; upon each of which are set other collateral points at the same angles, as the main points themselves; among these are divers other irregular, which are chiefly broken points or fragments of the regular ones; others also by various winds, seem to have been thawed, and frozen again into irregular clusters, so that it seems as if the whole body of snow was one entire mass of icicles irregularly figured; that is, a cloud of vapours being gathered into drops, the said drops do forthwith descend; and in their descent meeting with a freezing air, as they pass through a cold region, each drop is immediately frozen into an icicle, shooting itself into several points; but still continuing to descend, and meeting with some intermitting gales of warmer air, or by their being continually wafted to and fro, touching upon one another, some are a little thawed, blunted, and again frozen into clusters, or entangled, so as to fall into what we call flakes, although in reality snow is firm ice, and the lightness of it is owing only to the excess of its surface, in comparison to the contained matter, as a guinea can be so extended in surface as to ride upon the smallest breath of air."

And all so forming an harmonious whole,
Shade unperceiv'd, so softening into shade;
That as they still succeed, they ravish still.
But wandering oft, with rude inconscious gaze,
Man marks not thee, marks not the mighty hand
That, ever busy, wheels the silent spheres;
Works in the secret deep; shoots, streaming, thence
The fair profusion that o'erspreads the spring;
Flings from the sun direct the flaming day;
Feeds ev'ry creature; hurls the tempest forth,
And, as on earth this grateful change revolves,
With transport touches all the springs of life.

Thomson.

But besides the influence of snow as a guard, it is supposed, says Miller, in his Gardener's Dictionary, to abound with "*salific*" and "*fertile particles*."

Snow, says Evelyn, is to be reckoned among the manures, as containing a quantity of "nitrous particles," which is the *oxygen* of modern philosophy. The motto we have selected is a further corroboration of the prevalence of this notion.

Nor is this conclusion far from the truth, since the latest experiments, and most remarkable discoveries, which have contributed in the highest degree to the rapid progress of physics, have *proved* that snow and ice are waters possessing an high degree of oxygenation.

Hassenfratz being engaged in the examination of the nature of snow, found, when comparing this with rain water, a striking difference, which arose from the superior oxygenation of the snow.

"I put," says this philosopher, "1000 grammes* of snow in a jar, and the same quantity of distilled water in another.

"I poured upon each of the jars an equal quantity of the same solution of turnsole.

"I placed both jars in a warm temperature, and after the snow melted, I remarked that the tincture was redder in the snow water than in the distilled water.

"I repeated this experiment, and with the same result.

"I next put into a jar 1000 grammes of distilled water, and into another the same of snow.

"In each of these jars I put 6·5 grammes of very pure and clean sulphat of iron.

"In the first there was precipitated 0·150 of a gramme of the oxyd of iron, and 0·010 of a gramme in the other.

"As the oxyd of iron is precipitated from a solution of sulphat of iron solely by the quantity of oxygen, which meets it, and as the tincture of turnsole is reddened from the same cause, hence it follows that *snow* contains more oxygen than rain water."

Now a very considerable number of the plants which we have the art of appropriating for our nourishment, are sown in the month of Vendemaire,

---

* A gramme is equal to 15·4457 grains Troy.

Brumaire, and even Frimaire (from the month of September to the latter end of December), and the seeds thus abandoned and exposed to an inclement season are soon after sheltered by the snows, which cover them, and when it melts, they are then acted upon by a *superoxygenated* water, which has a powerful operation on them, and greatly hastens on the principle of germination. The Lapland year is very remarkable.

THE LAPLAND CALENDAR.

June 23. *Snow melts.*
July 1. *Snow gone.*
9. Fields quite green.
17. Plants in full blow.
August 2. Fruits ripe.
10. Plants shed their seed.
18. *Snow.*

From this time to June 23d, *snow* and *ice*.

So that, by this account, plants, from the coming out of the ground to the ripening of their seeds, take but a month, and the spring, summer, and autumn, are crowded into the space of fifty-six days.

The astonishing progress of the Siberian, or Lapland year, is finely depicted by Beattie, and certainly must in part be ascribed to the fertilizing influence of melted snow.

Lo! on the chill Lapponian's dreary land,
For many a long month lost in *snow* profound,
When Sol from Cancer sends the season bland,
And in northern cave the storms hath bound,
From silent mountains, straight with startling sound,
Torrents are hurl'd, green hills emerge, and soon
The trees with foliage, cliffs with flowers are crown'd;
Pure rills through vales of verdure warbling go;
And wonder, love, and joy, the peasant's heart o'erflow.

Beattie.

SECT. XIV.

IX. OF THE UTILITY OF WINDS.

Sylphs! your light troops the tropic winds confine,
And guide their streaming arrows to the line;
While in warm floods ecliptic breezes rise,
And sink with wings benumb'd in colder skies.
You bid monsoons on Indian seas reside,
And veer, as moves the sun, the airy tide;
While southern gales o'er western ocean roll,
And Eurus steels his ice-winds from the pole.

Darwin.

Having discoursed on the months Frimaire and Nivose (December and January), marked by ice and snow, which we have shewn to be highly *oxygenated* waters, we are arrived next at the month, February, which, in our new English Calendar, we have designated by the *Thawing Month*.

In this month the sun occasionally bursts out and melts the ice and snow covering the earth, which circumstance is thus beautifully described by our first of English poets:

.....When white winter o'er the shivering clime
Drives the still snow, or showers the silver rime;
As the lone shepherd o'er the dazzling rocks
Prints his steep step, and guides his vagrant flocks;
Views the green holly veil'd in network nice,
Her vernal clusters twinkling in the ice;
Admires the lucid vales, and slumbering floods,
Fantastic cataracts, and crystal woods,
Transparent towns, with seas of snow between,
And eyes with transport the refulgent scene:....

If breaks the sun-shine o'er the spangled trees,
Or flits on tepid wing the western breeze,
In liquid dews descends the transient glare,
And all the glittering pageant melts in air.

DARWIN.

The glebe being resolved, the month next in succession is Ventose (March), or, in our New English Calendar, the *Windy Month.*

The air being at this time compressed by cold, a greater quantity of *oxygen* is found in a given volume, and the winds act as a kind of bellows to the earth.

Thus more *oxygen* is absorbed by the land, and the beneficial process of *oxygenation* is still further carried on.

SECT. XV.

X. WHY RAIN PROMOTES GERMINATION MORE THAN SPRING OR RIVER WATER?

Aquatic Nymphs! you lead, with viewless march,
The winged vapours up the aerial arch,
On each broad cloud a thousand sails expand,
And steer the shadowy *treasure* o'er the land,
Through vernal clouds the gathering drops diffuse,
Plunge in soft rain, or sink in silver dews.

Darwin.

The irregular showers of April (the month *Pluviose* of the new Calendar) is a benevolent contrivance of Nature to bring into action the seeds committed to the bosom of the earth.

The farmer and gardener deriving their water from springs and rivers, have in vain tried to imitate these fecundating showers.

The reason of the great fertilizing power of rain is the discovery of modern philosophy.

From the experiments of Hassenfratz it appears that, under an exhausted receiver, rain-water suffers air to escape from it, and, upon examination, this air contains a greater proportion of *oxygen* than either river water, spring water, or even atmospheric air.

For atmospheric air exposed to the action of phosphorus, without the application of heat, after the method indicated by Berthollet, is diminished 21 degrees; that is to say, the phosphorus* takes 21 parts of oxygen out of 100 parts of atmospheric air.

* The theory of this experiment is as follows. *Phosphorus* is a simple body. *Air* is composed of oxygen air and azotic air. The *phosphorus* coming into contact with *common air* obeys the laws of elective attraction, and it unites with the *oxygen* of the atmosphere, *heat* and *light* are liberated, and the *phosphorus* is converted into *phosphoric acid,* a concrete body, accounting for the disappearance of the *oxygen air.* Hence its use, as well as nitrous air, to ascertain the quantity of *oxygen* in any given quantity of air.

Air drawn from the water of the Seine, tried by the same eudiometer, gave nearly the same diminution.

Air drawn from rain-water was, on the other hand, diminished by phosphorus from 32 to 40 degrees.

As the mean of a great number of experiments was 35 degrees, it thence follows that the proportion of oxygen in the air obtained from rain-water, newly fallen, is greater and more considerable than that contained in atmospheric air, and in the air of other waters.

Sir Francis Ford discovered, that seeds germinated much sooner, and became more vigorous, when he moistened the pot containing them with water impregnated with oxygen air*.

Since rain-water thus differs from pump and other waters by the quantity of *oxygen* held in solution, and since oxygen has so great an influence on germination and on vegetation, as is proved by the experiments of Ingenhousz, Senebier, and Sir Francis Ford, it is but just to ascribe to it a part of the peculiar action which *rain* has on the vegetation of plants different from that of other water with which they may be supplied.

---

* The manner water is impregnated with oxygen air is as follows. The pump, or river water, must be first boiled, which forces out the atmospheric air from the interstices of the water, and being afterwards placed in contact with the *oxygen air*, as it cools, it imbibes this enlivening principle.

SECT. XVI.

XI. ON THE POWER OF CERTAIN OXYGENATED SUBSTANCES TO ACCELERATE THE PROCESS OF GERMINATION.

Hence in fine Streams diffusive *Acids* flow.

DARWIN.

As all the Acids resemble each other in their taste; in their giving a red colour to litmus, and other blue vegetable substances; in their tendency to coalesce with alkalies, and metallic bodies; the immortal MAYOW* first proclaimed to the world, that they must possess some *common principle*; and chemical analysis, advanced as it is at the present day, has put this opinion beyond the possibility of a doubt.

---

* De acidorum ortu, Ch. iv. or vide an Analysis of Mayow's work by the celebrated Dr. Beddoes, who has the honour of first bringing into light the merit of him, whom he has justly styled the "Philosopher of the last century." For some time, says Dr. Beddoes, though I had often tried to procure for myself Mayow's five Treatises, I had only been able to see them within the precincts of a college library, so scarce is his publication, and should I ask, who of all our acquaintance, is the person least likely to be overtaken by surprize, you would, I think, name a certain northern professor (Dr. *Black)*, to whom both of us owe great obligations, yet at the sight of the plates, representing Mayow's chemical apparatus, this sedate philosopher lifted up his hands in complete astonishment. I have deduced, adds Dr. Beddoes, as well as I can, the history of Mayow's writings to our own times. Henceforward, I flatter myself, that he will share the glory of VERULAM and NEWTON, and be named with due respect by all, by those especially who have perused his work; and that when the enthusiasm of an Englishman salutes his country, as

Magna parens frugum!——
Magna virum!——

MAYOW will be ranked among the foremost of her illustrious men. He continues with his usual candour, Should any one now inquire, in the simplicity of his heart,—for if the question were dictated by any other spirit, I should bid the inquirer seek information for himself,—whether the name of honour, due to the *moderns*, is to be found by subtracting the share of MAYOW, let him be assured, *that the discoveries of our times set out from a different point, and proceeded in a different train, in perfect ignorance of him, and therefore without any assistance from him.*

The philosopher of the last century even went so far as to declare this *common principle* to be the " NITRO-AERIAL PARTICLES" (the *oxygen* of modern times) which unite with different bases, and thus constitute the several acids.

In his fourth chapter, " on the origin of acids," we see him combating the received opinion, " denying that the vitriolic acid is contained in Sulphur before deflagration."

He attributes " its change to the affinity its base has for the *nitro-aerial particles*, which convert the sulphur into sharp sword-like atoms, giving them the poignancy which constitutes the character of an acid."

" If vitriol," says he, " be calcined till the acid be totally expelled, and then exposed to the air, it will be anew impregnated with an acid, by the slow combination of the *nitro-aerial particles* with the sulphur; for it is impossible to conceive in what other way the spirit of vitriol can be regenerated."

" The rust of iron also is produced by the *nitro-aerial particles* attacking the iron; and the effect of exposure to *air* is only a slower process, as if the iron were moistened by some *acid*."

How consonant are these ideas with the doctrines of modern chemistry!

The unfortunate LAVOISIER in a series of Essays* taught his ungrateful countrymen " the composition of the vitriolic, phosphoric, and nitrous acids."

" Many additional experiments," says this Philosopher in Essay VIII. have enabled me to generalise this doctrine, and to pronounce that this *pure* and *highly respirable air* is the constitutive principle of acidity; that this principle is common to all acids; and that the difference by which they are distinguished from each other is produced by the union of one or more principles, besides *this air*, so as to constitute the particular form under which each acid appears."

Having premised thus much respecting the nature and composition of acids, we come now to the consideration of the important experiments of HUMBOLDT, which were made in the year 1793.

---

* Vide Essays, or Memoirs, read before the Royal Academy of Sciences, translated by Thomas Henry, F. R. S.

EXPERIMENT I.

This experimentalist first mixed the *oxygenated muriatic acid gas** with water, and CRESSES *(the Lepidium sativum of Linnæus)* were immersed in it, and these shewed signs of germination at the end of *six* hours.

EXPERIMENT II.

The same being treated in a similar manner in common water, did not exhibit their germs until the end of *thirty* hours.

These experiments were made at the temperature of from 57° to 60°.

OBS. The action of the oxygenated water was *immediately* shewn by an enormous quantity of air-bubbles, which covered the surface of the seeds: a phænomenon not exhibited in common air till after *thirty* or *forty* minutes.

EXPERIMENT III.

In the summer of 1796, HUMBOLDT began a new series of experiments, and found that by an increased degree of heat, the *oxygenated water* still more remarkably accelerated the process of germination.

The temperature was raised to 88° of Fahrenheit.

---

* All acids are combinations of radicals, or acidifiable substances, different in each species, with *oxygen,* which is the same in all: whence it follows, that their *common properties,* their characters as acids, depend on *oxygen*;—their *particular properties,* their *specific characters* arise from their *radicals.*

Each radical may be also contemplated in four states.

1st, As containing very little *oxygen,* not sufficient to impart to it the nature of an acid, and in this it is nothing more than an *oxyd;* such is sulphur coloured red or brown, by exposure to air, and a degree of heat inadequate to produce combustion.

2dly, Containing more *oxygen* than in the preceding case, and enough to become an acid, though weak, when it is called the *sulphureous acid.*

3dly, Possessing still more *oxygen* than in the second instance, and having acquired powerful acid properties, then the termination is not in *ous,* but in *ic,* and it is then styled the *sulphuric acid.*

4thly Conjoined with a still larger dose of *oxygen,* when instead of the last termination, the term *oxygenated* is used.

Thus the character of the *muriatic acid,* gaseous or fluid, is its having a pungent smell, unalterable by any known combustible substance, on the contrary attracting oxygen from several burnt, or oxygenated, bodies, particularly from metallic oxyds, and thus becoming *oxygenated muriatic acid.*

The *oxygenated muriatic acid* is remarkable for these properties, its greenish yellow appearance; its power of divesting vegetable substances of all colour; burning and inflaming most combustible substances; and forming with potash a salt, which rapidly sets fire to heated inflammable substances; and affords the purest *vital air* known.

Equal quantities of Garden cresses *(Lepidium sativum)* were thrown into the water, mixed with the *oxygenated muriatic acid.*

These exhibited their germs very rapidly in the *oxygenated* water, even in *three* hours.

EXPERIMENT IV.

Whereas those in *common water,* under the same circumstances, did not take place until the end of *twenty-six* hours.

EXPERIMENTS V...VIII.

The same result arose in comparative experiments with Peas *(Pisum sativum),* French Beans *(Phaseolis vulgaris),* Garden Lettuce *(Lactuca sativa),* and Mignonette *(Reseda odorata.)*

EXPERIMENT IX.

The philosophic mind generally pushes forward every new discovery, and we find Humboldt in the same year endeavouring to cause to germinate the Clusia rosea (*Rose Clusia),* the seeds of which had been brought from the Bahama Islands by Boose, and which before had resisted every attempt to make them vegetate.

For this purpose he employed a new process, which promises hereafter to be a great acquisition for the raising of foreign seeds of difficult growth.

He formed a paste, by covering the seeds with the *black oxyd of Manganese,* and then sprinkled over them the *muriatic acid* diluted in water.*

The temperature was 95° of Fahrenheit.

The theory of this process is as follows....The *oxygen* in the *black oxyd of Manganese,* quits the *metallic body,* to unite with the *muriatic acid,* to which it has a greater affinity, and in consequence it becomes highly *oxygenated muriatic acid.*

---

* The proportion used were six measures of water to one of the muriatic acid.

As such it imparts its *oxygen* to the vegetable fibre, and thus accelerates the first actions of life; returning back to its pristine state of simple *muriatic acid.*

EXPERIMENT X.

These interesting experiments have been repeated with great industry by several distinguished philosophers.

Professor POHL at Dresden caused to germinate in water mixed with the *oxygenated muriatic acid,* the seeds of a new kind of EUPHORBIA, taken from Bocconi's collection of dried plants, 120 years old, which were supposed through time to have lost their vegetative power.

EXPERIMENT XI...XXX.

JACQUIN and Vander SCHOTT at Vienna, threw into the diluted *oxygenated muriatic acid* all the old seeds, which had been kept at the Botanic Garden, after they had been in vain before attempted to be made to germinate, and the greater part of them succeeded.

Among these were the seeds of the NICKAR TREE *(Guclandina bonduc),* the PIGEON PEA *(Cytysus Cajan),* the NARROW-LEAVED DODONÆA *(Dodonæa angustifolia),* the CLIMBING SENSITIVE PLANT *(Mimosa scandens),* and several new species of the HOMÆA.

EXPERIMENT XXXI.

There are now to be seen at Vienna very many valuable plants, which are entirely arising from the *oxygenated muriatic acid.*

Von USLAR, in his Chemico-Physiological observations on plants, relates that he took different seeds of different plants, and caused an accumulation of *oxygen* in some, while no such accumulation took place in the rest, and found that, under certain circumstances, the first germinated sooner, and grew quicker than the latter.

In order to dispose plants for imbibing more *oxygen,* it is necessary to apply to them bodies, which contain *oxygen* but weakly combined, or from which it is easily separable, and whose basis has less attraction to *oxygen* than the vegetable matter has; and such a body is the *oxygenated muriatic acid.*

This Philosopher sowed the LEPIDIUM SATIVUM *(garden Cress)* in two different pots; the earth of the one he moistened with *pure river water,* and that of the other with the same kind of water mixed with the super-oxygenated *muriatic acid.*

The seeds in the *latter* germinated much sooner than in the *former,* which was only moistened with pure water, and which consequently could not communicate to the plants so much *oxygen* as the other, and thence too, the plants in it were much retarded in their growth.

EXPERIMENT XXXIII....XXXV.

The results from experiments made with other seeds; for instance, with the FIELD CABBAGE *(Brassica campestris),* TURNEP *(Brassica napus),* and COMMON PEA *(Pisum sativum),* exactly coincided with the experiment before mentioned.

In order to ascertain in a more satisfactory manner, that the greater proportion of *oxygen* caused the vigorous and quick growth of plants, VON USLAR varied his experiment.

He took pounded quartz instead of earth, and moistened one portion of it with the *superoxygenated acid,* and another portion with *pure water*; and the result was the same as in the former trials.

EXPERIMENT XXXVI...XXXVIII.

If the seeds, says Dr. HOOPER, of Pembroke College, Oxford, in his excellent epitome, (entitled, Observations on the Structure and Œconomy of Plants), of PHASEOLUS, PISUM, and LEPIDIUM, (the *Bean, Pea,* and *Cress)* be put into silicious earth, (powdered flint-stone), and sprinkled with water mixed with a portion of the *oxygenated muriatic acid,* for in no acid does *oxygen* so abound and so laxly adhere, they germinate much sooner than if sprinkled with *pure water.*

EXPERIMENT XXXIX....XLI.

A small portion of *nitre** in water I found, adds this accurate observer

* The great quantity of *oxygen* contained in nitre is shewn in note (†) page 60.

of Nature, to cause the Hyacinth, Narcissus, and other bulbous plants, to germinate much sooner than they otherwise would have done.

EXPERIMENT XLII....XLV.

Pursuing the inquiry, HUMBOLDT found that metallic bodies simply did not promote germination, but that metallic *oxyds* favour it, and that, in the exact proportion of the degree of *oxydation** of the metal.

VON USLAR has confirmed these experiments, and observes that, even in the *oxyd of lead* (litharge), he found that plants grew very well, and better indeed than in pure earth.

And the learned Dr. Darwin in his PHYTOLOGIA† mentions, that he has

---

* Not only do all metals compared with each other absorb different quantities of *oxygen* to saturate them in their combustion by the contact of air, but each metal considered separately absorbs different proportions, and stops at various points of *oxydation*, according to the degree of temperature to which it is raised. Thus tin, lead, copper, iron, change colour and assume the *tints* of the *rainbow*, at the first degree of fire to which they are exposed in contact with the air; LEAD first becomes a *grey oxyd*, next *yellow*, and lastly *red*; MERCURY passes from *black* to *white*, from white to *yellow*, and from yellow to *red*; IRON, at first a *black* oxyd, becomes next *green*, then *brown*, and ultimately *white*; COPPER is at first a *brown oxyd*, from which it changes to *blue*, and its last degree of *oxydation* imparts to it a *green* colour.

† The PHYTOLOGIA of this able writer arose from a circular letter sent round by the Board of Agriculture, proposing queries respecting numerous points, relative to the growth and cultivation of plants, and it contains a concise account of all the most important discoveries, that have any connexion with the subject of Botany, and these are so nicely arranged, and digested, with new observations from the author, as to form a work, that may certainly boast of being the first *Philosophic Treatise* upon so interesting a branch of Science. My NEW ILLUSTRATION of the SEXUAL SYSTEM of LINNÆUS, was begun long before the appearance of Dr. Darwin's elaborate work, and the plan publicly proposed, and I have to rejoice that our respective performances do not interfere, but must mutually advance each other. Dr. Darwin addresses his readers, as already conversant in botany and adepts in the new chemistry. My work supposes in my readers a total unacquaintance with all kind of chemical and botanical knowledge, and I expatiate on the several subjects I have to treat of, and lead my readers, step by step, from lesser to higher flights, enforcing all the while my instructions, by plates, which from their fine execution, (as is universally allowed,) " may be as a substitute for the plants themselves," which I conceive to be the readiest way of attaining a knowledge of the useful and delightful science of Botany. For, as the great ROUSSEAU justly laments to the Duchess of Portland, in his Letters, " No such work was to be found, in his time, and as plants bloomed at different seasons, and could not always be procured, to acquire a knowledge of Botany from the BOOK OF NATURE was a tedious and almost insurmountable attempt." In a few words, my work is chiefly *elementary*, Dr. Darwin's wholly *philosophic*; and I take this opportunity of expressing the great obligations I owe to the PHYTOLOGIA, as well as to Dr. Darwin's two immortal poems, the ŒCONOMY OF VEGETATION, and LOVES OF THE PLANTS, which have so often served to enliven the heads of the several sections, by furnishing an appropriate motto. As an excuse for some liberties taken with the text, vide note *, page 41, I must beg leave to add also, that the notes of the BOTANIC GARDEN contain a fund of useful erudition. Indeed, all Dr. Darwin's writings are intrinsically excellent, and superior to my feeble praise.

been creditably informed, that a *red ocher of iron,* called reddle,* has been used on some lands with advantage in the north of Staffordshire.

EXPERIMENT XLVI.

HUMBOLDT made experiments with the *muriatic,*† *nitric,*‡ and *sulphuric acids,*§ pure, and mixed with water, and he found that these produced no sensible effect in promoting germination.

The reason of which appears to be this: The *oxygen* of these acids is too firmly attached to their respective radicals, to be disengaged, and act on the affinities presented them by the vegetable fibre.

CONCLUSION.

Hence we presume, we may be warranted to conclude, that OXYGEN when *combined* with *certain radicals* has a *great effect* in *accelerating the process of germination.* ‖

---

* *Reddle,* or *Red Chalk,* is a calciform ore of iron, termed in the new nomenclature, the *yellow* oxyd of *iron.*

† For an account of the *muriatic acid,* vide note (*), page 79.

‡ The *nitric acid* is liquid, white, caustic, of a strong and nauseous smell, and is formed of *azot* and *oxygen.* The *nitrous acid* is the same as the *nitric acid,* except in having a smaller portion of *oxygen,* and is composed of one part *azot,* to three parts *oxygen,* which was first discovered by the Hon. Mr. Cavendish, who put three parts *oxygen air,* to one of *azot,* into a bell glass, and by passing the *electric fire* through that mixture, caused them to combine, and hence produced the *nitrous acid;* such are the wonderful changes resulting from a new combination of simple elements!

§ The *sulphuric acid* is formed of *sulphur* and *oxygen,* by the combustion of sulphur; it is inodorous, and twice as heavy as water. The *sulphureous acid* only differs from this in containing less oxygen, but has, on the contrary, a very powerful smell.

‖ This subject will be resumed when we come to treat on the Principles of Agriculture, when we shall relate at length the experiments of Dr. Ingenhousz, who proposed to the Board of Agriculture a scheme of quickly *oxygenating,* by means of *acids,* the earth, to prevent the necessity of *fallowing;* and he obtained the Gracious Permission of THE KING, who has ever with parental solicitude encouraged the *plough,* to try these experiments upon any part of the land cultivated by HIS MAJESTY.

SECT. XVII.

XII. OF THE EARTH'S INTERNAL HEAT.

NYMPHS! your fine forms with steps impassive mock
Earth's vaulted roofs of adamantine rock;
Round her still centre tread the burning soil,
And watch the billowy lavas as they boil;
Where in basaltic caves imprison'd deep,
Reluctant fire in dread suspension sleep;
Or sphere on sphere in widening waves expand,
And glad with GENIAL WARMTH *the incumbent land*
So when the mother-bird selects their food
With curious bill, and feeds her callow brood;
Warmth from her tender heart eternal springs,
And pleased she clasps them with extended wings.

DARWIN.

ALL the heat we meet with here on the earth we are ready at once to ascribe to the action of the sun, overlooking that produced within the earth itself, which we shall in this section attempt to shew to be very considerable.

We learn from the most correct observations, that in the cave of the observatory at Paris, only about 90 feet under ground, the heat keeps the thermometer at 53° of Farhenheit; and this without any assistance from the sun; it being never sensibly increased by the most scorching seasons one degree beyond its heat in the most severe winters that have ever been experienced there.

And the same constant and unalterable degree of heat was observed by the honourable Mr. Boyle in a cave cut deep into the earth.

Great and even troublesome heats are said to have been observed at greater depths, and always increasing in proportion to these depths.

Morinus (de locis subterraneis) relates that in the mines of Hungary, which are 500 cubits deep, the heat becomes very troublesome when the miners get below 480 feet deep.

The accurate Mons. de Luc in going 1359 feet perpendicular in the mines of Hurtz, on July 5, 1778, on a very hot day found the air at the bottom warmer than that at top of the shaff.

Lord Verulam, and others, have remarked the various temperatures of the air in different places of the earth do by no means correspond to what should be the result of their position to the sun.

To omit variations that are small and of less moment, I shall only take notice of the much greater cold in all the southern hemisphere than in those of the same latitude on the European side of the globe.

All which seems to argue a copious fund of some other more potent cause of heat than the regular action of the sun; and that cause is inherent in the earth itself, and is stronger in some regions than in others, though every where considerable and of great force.

Various have been the opinions of philosophers relative to the cause of this phænomenon.

Mons. de Mairon, in a paper published in the Histoire de L'Academie de Sciences, in 1765, has conjectured, that the earth's internal heat must proceed from fires kindled within the earth at its center.—

First, from the warm springs found in many parts of the earth, as Bath, Aix la Chapelle, which have kept the same temperature at all seasons, and through so many centuries.*

Secondly, the frequent eruptions of burning mountains, which have astonished mankind through every age.

Thirdly, the very distant and expeditious communication of the shocks of some great earthquakes.

That of Lisbon in 1755 was perceived even in Scotland and many more distant parts.

---

* These *hot springs* are always the same; for the longest and heaviest rains do not caufe them to give out more water, nor the driest seasons occasion them to discharge less.

These phænomena are easily explained, says the celebrated Dr. Darwin, if we suppose the central part of the earth to consist of a *fluid Lava,** as a percus-

---

* The matter which is found to roll down from the mouth of all volcanos in general, resembles the dross that is thrown from a smith's forge. But it is different, perhaps, in various parts of the globe; for, there is not a quarter of the world that has not its volcanoes. In *Asia*, particularly in the islands of the Indian ocean, there are many. One of the most famous is that of Albouras, near mount Taurus, the summit of which is continually on fire, and covers the whole adjacent country with ashes. In the island of Ternate there is a volcano, which, some travellers assert, burns most furiously in the times of the equinoxes, because of the winds which then contribute to increase the flames. In the Molucca islands there are many burning mountains; they are also seen in Japan, and the islands adjacent; and in Java and Sumatra, as well as in other of the Philippine islands. In *Africa* there is a cavern, near Fez, which continually sends forth either smoke or flames. In the Cape de Verde islands, one of them, called the Island del Fuego, continually burns; and the Portugueze, who frequently attempted a settlement there, have as often been obliged to desist. The Peak of Teneriffe is, as every body knows, a volcano that seldom desists from eruptions. But of all parts of the earth, *America* is the place where those dreadful irregularities of nature are the most conspicuous. Vesuvius, and Ætna itself, are but mere fire-works, in comparison to the burning mountains of the Andes; which, as they are the highest mountains of the world, so also are they the most formidable for their eruptions. The mountain of Arequipa in Peru, is one of the most celebrated; Carassa, and Malahallo, are very considerable; but that of Cotopaxi, in the province of Quito, exceeds any thing we have hitherto read or heard of. The mountain of Cotopaxi, as described by Ulloa, (Ulloa, vol. i. p. 442) is more than three miles perpendicular from the sea; and it became a volcano at the time of the Spaniards' first arrival in that country. A new eruption of it happened in the year 1743, having been some days preceded by a continual roaring in its bowels. The sound of one of these mountains is not like that of the volcanoes in Europe, confined often to a province, but is heard at an hundred and fifty miles distance. An aperture was made in the summit of this immense mountain; and three more about equal heights, near the middle of its declivity, which was at that time buried under prodigious masses of snow. The ignited substances ejected on that occasion, mixed with a prodigious quantity of ice and snow, melting amidst the flames, were carried down with such astonishing rapidity, that in an instant the valley from Callo to Latucunga was overflowed; and besides its ravages in bearing down the houses of the Indians, and other poor inhabitants, great numbers of people lost their lives. The river of Latucunga was the channel of this terrible flood; till being too small for receiving such a prodigious current, it overflowed the adjacent country, like a vast lake, near the town, and carried away all the buildings within its reach. The inhabitants retired into a spot of higher ground behind the town, of which those parts which stood within the limits of the current were totally destroyed. The dread of still greater devastations did not subside for three days; during which, the volcano ejected cinders, while torrents of melted ice and snow poured down its sides. The eruption lasted several days, and was accompanied with terrible roarings from its crater, rushing through the volcano still louder than the former rumblings in its bowels. At last all was quiet, neither fire nor smoke to be seen, nor noise to be heard; till, in the ensuing year, the flames again appeared with recruited violence, forcing their passage through several other parts of the mountain, so that in clear nights the flames being reflected by the transparent ice, formed an awfully magnificent illumination."

Such is the appearance and the effect of those fires which proceed from the more *inward recesses* of the earth; for that they generally come from deeper regions than man has hitherto explored, I cannot avoid thinking, contrary to the opinion of BUFFON, who supposes them rooted but a very little way below the bed of the mountain. "We can never suppose," says this great naturalist, "that these substances are ejected from any great distance below, if we only consider the great force already required to fling them up to such vast heights above the mouth of the mountain; if we consider the substances thrown up, which we shall find upon inspection to be the same with those of the mountain below; if we take into our consideration, that air is always necessary to keep up the flame; but, most of all, if we attend to one circumstance, which is, that if these substances were exploded from

sion on one part of such a fluid mass would be felt on other parts of its confining vault, like a stroke on a fluid contained in a bladder, which however gentle on one side, is perceptible to the hand placed on the other; and the velocity with which such a concussion would travel would be that of sound, or thirteen miles in a minute.

Hence Dr. Darwin has been led to conjecture in his beautiful poem on the œconomy of vegetation, that the first act of the ALMIGHTY was the Creation of innumerable Suns.

> "LET THERE BE LIGHT!" proclaim'd the ALMIGHTY LORD. . . .
> *Astonish'd Chaos* heard the potent word;—
> Through all his realms the kindling Ether runs,
> And the mass starts into a million *Suns*.*

---

a vast depth below, the same force required to shoot them up so high, would act against the sides of the volcano, and tear the whole mountain in pieces." To all this specious reasoning particular answers might easily be given; as that the length of the funnel increases the force of the explosion; that the sides of the funnel are actually often burst with the great violence of the flame; that air may be supposed at depths at least as far as the perpendicular fissures descend. But the best answer is a well-known fact; namely, that the quantity of matter discharged from Ætna alone, is supposed, upon a moderate computation, to exceed twenty times the original bulk of the mountain. (Kircher, Mund. Subt. vol. i. p. 202.) The greatest part of Sicily seems covered with its eruptions. The inhabitants of Catanea have found, at the distance of several miles, streets and houses, sixty feet deep, overwhelmed by the lava or matter it had discharged. But what is still more remarkable, the walls of these very houses have been built of materials evidently thrown up by the mountain. The inference from all this is very obvious; that the matter thus exploded cannot belong to the mountain itself, otherwise it would have been quickly consumed; it cannot be derived from moderate depths, since its *amazing quantity* evinces, that all the places near the bottom must have long since been exhausted; nor can it have an extensive, and, if I may so call it, a superficial spread, for then the country round would be quickly undermined; it must, therefore, be supplied from the *deeper regions* of the earth; those undiscovered tracts where the DEITY performs his wonders in solitude! Vide GOLDSMITH'S HISTORY OF THE EARTH, Vol. I. p. 91—96.

* This assemblage of vast bodies is divided into different *systems*, the number of which may perhaps exceed the grains of sand which the sea casts on its shores.

Each system has its center or focus, call it either a fixed star or sun, which shines with its own light, and round which revolve various orders of opaque globes, which reflect with greater or lesser lustre the light they borrow from it, and which renders them visible to us.

These, which seem to wander among the heavenly bodies, are *planets*, the principal of which have what we call *the sun* for the common center of their periodical revolutions; whilst the others, which are styled secondary, move round one principal planet, which they accompany like satellites, in its annual revolution.

Venus and the *Earth* have each of them their satellite. One will undoubtedly be some time or other discovered in *Mars*. *Jupiter* has four, *Saturn* five, and a ring or luminous body which seems to perform the office of a number of small moons. Being situate near three hundred millions of leagues from the sun, he would have received too faint a light from it, if his satellites and ring did not augment it by reflection.

We have discovered *twenty-seven planets*, which at present compose *our solar system*; but we

The planets are next represented to emanate from these suns, and their moons and satellites to be derived from them.

> GNOMES! your bright forms, presiding at her birth,
> Clung in fond squadrons round the new-born *Earth*;
> When high in ether, with explosion dire,
> From the deep craters of his realms of fire,
> The whirling Sun this pond'rous planet hurl'd,
> And gave the astonish'd void another world.
>
> GNOMES! how you gaz'd! when from her wounded side
> Where now the South-Sea heaves its waste of tide,
> Rose on swift wheels the *Moon's* refulgent car,
> Circling the solar orb, a sister star.

The celebrated French Naturalist* represents the DEITY as employing a Comet in the work of creation.

This impinging with immense power on the *sun*, just as particles of fire are driven from a flint when struck by a steel, so those bodies which form

---

are not certain that there are not more of them. Their number has received a great increase by the invention of telescopes: more perfect instruments, and more assiduous and accurate observers, may probably make some further addition to them. The satellite of Venus, of which there was a discovery made in the last century, and of the *Georgium Sidus* in the present, gives room for astronomers to expect a still greater augmentation of their number.

The diameter of the great orbit, which our planet describes round the Sun, is more than sixty millions of leagues, and this vast circumference vanishes into nothing, and becomes a mere point, when made use of by astronomers to measure the distance of the *fixed stars*.

How great then must be the real bulk of those spotlike stars, that are perceivable by us at such an enormous distance! The sun is about a million times greater than the earth, and an hundred and ten times greater than all the planets put together.

If the stars are *suns*, as their lustre gives us reason to suppose, how greatly must they surpass our earth in size!

The stars, when seen through a telefcope, are innumerable: their sparkling affords a proof that they shine with their own light; and since they are visible to us at incomparably greater distances than Saturn, we may from thence infer that they are so many *suns*. Our sun, if viewed from a star, would itself appear like a star. There must then be an *infinite number of suns*; and to what purpose would they serve, if there were not Beings capable of enjoying the advantages of their light and heat? Is it not therefore natural to suppose, that they give light to other worlds, which their prodigious distance deprives us of, and possess also their several productions and inhabitants. How transcendent the idea, that these systems are all stored with Beings, created by a GOD, who wanted no fresh accessions to HIS happiness!

Thus it is that night conveys to the mind a much grander conception of infinity than the day-time. In the glare of day I behold but one sun; but in the night I discern *myriads*.

The light discovers to me only a terrestrial infinity, but the darkness discloses an infinity altogether *celestial*.

* BUFFON. Vide his Theory of the Earth, Vol. I.

our solar system, including the earth, and moons, with the several satellites, broke from the *Sun's substance,* and were scattered over the vast inane.

Being driven with an impulsive force they would have receded for ever, had not God endowed the sun with an attractive power, which, operating as the planets lost something of their direct motion, produced those circumgirations which they now possess.

As the fluid Earth was impelled forward, it rolled round and round, and then obtained its oblate, or spheroid figure, producing the vicissitudes of night and day: and as our globe was once a part of the sun, it still continues at its center to be an uniform mass of melted matter, in its state of primeval fusion.

But its surface is very differently composed.

Having been in the beginning heated to a degree equal to, if not greater, than what comets are found to sustain, most things were in a state of vapour, which subsiding, in proportion as the substance cooled, formed, according to their several densities, earth, water, air; the heavier parts sinking, and the lighter still remaining suspended.

By degrees things took their proper stations.

The waters covering the earth, formed for themselves beds, and mountains rose.*

And the Earth was then, by the Almighty Fiat, to bring forth grass, and the herb yielding seed, and the fruit tree yielding fruit, each after his own kind...next living creatures, cattle, birds, fishes, insects...and lastly, the paragon of creation, Man.

> Next Love Divine, with brooding wings unfurl'd,
> Call'd from the rude abyss the *living world.*
>
> Darwin.

I shall now present my readers with the opinion of the celebrated Dr. Whiston, who supposes "the earth to have been originally not the spark of a sun, but actually a *comet*; and considers the history of the creation, as given us in Scripture, to have its commencement just when it was, by the

---

* There is something infinitely more simple and grand in the scriptural account of the Almighty being *six days* employed in the *Work of Creation,* than in this slow progress of the Earth towards its perfection.

hand of the Creator, more regularly placed as a planet in our solar system.

Before that time, he supposes it to have been a globe without beauty or proportion; a world in disorder; subject to all the vicissitudes which comets endure; some of which have been found, at different times, a thousand times hotter than melted iron; at others, a thousand times colder than ice.

These alterations of heat and cold, continually melting and freezing the surface of the earth, he supposes to have produced, to a certain depth, a chaos entirely similar to that described by the poets, surrounding the solid contents of the earth, which still continued unchanged in the midst, making a great burning globe of more than two thousand leagues in diameter. This surrounding chaos, however, was far from being solid: he resembles it to a dense though fluid atmosphere, composed of substances mingled, agitated, and shocked against each other; and in this disorder he describes the earth to have been just at the eve of creation.

But upon its orbit being then changed, when it was more regularly wheeled round the sun, every thing took its proper place; every part of the surrounding fluid then fell into its situation, in proportion as it was light or heavy.

The middle, or central part, which always remained unchanged, still continued so, retaining a part of that heat which it received in its primeval approaches towards the sun; which heat, he calculates, may continue for about six thousand years!

Next to this fell the heavier parts of the chaotic atmosphere, which serve to sustain the lighter: but as in descending they could not entirely be separated from many watery parts, with which they were intimately mixed, they drew down a part of these also with them; and these could not mount again after the surface of the earth was consolidated: they, therefore, surrounded the heavy first descending parts, in the same manner as these surround the central globe.

Thus the entire body of the earth is composed internally of a great *burning mass*; next which is placed an heavy terrene substance, that encompasses it; round which also is circumfused a body of water.

Upon this body of water the crust of earth on which we inhabit is placed: so that, according to him, the globe is composed of a number of coats, or shells, one within the other, all of different densities.

The body of the earth being thus formed, the air, which is the lightest substance of all, surrounded its surface; and the beams of the sun darting through, produced that light which, we are told, first obeyed the Creator's command.

The whole œconomy of the creation being thus adjusted, it only remained to account for the risings and depressions on the surface of the earth, with the other seeming irregularities of its present appearance.

The hills and vallies are considered by him as formed by their pressing upon the internal fluid, which sustains the outward shell of the earth, with greater or less weight: those parts of the earth which are heaviest, sink into the subjacent fluid more deeply, and become vallies: those that are lightest, rise higher upon the earth's surface, and are called mountains.

Such was the face of nature before the deluge; the earth was then more fertile and populous than it is at present; the life of a man and animals was extended to ten times its present duration: and all these advantages arose from the *superior heat* of the central globe, which ever since has been cooling.

As its *heat* was then in *full power,* the genial principle was also much greater than at present; vegetation and animal increase were carried on with more vigour; and *all nature seemed teeming with the seeds of life.*"

But I find I am now treading on slippery and enchanted ground. I shall hasten, therefore, to another explanation of this curious phœnomenon, less dependent on conjecture.—I fear I may be thought by some already to have gone too far into the bewitching and airy regions of fancy and conjecture.

SECT. XVIII.

THE SAME SUBJECT CONTINUED;

WITH A PARTICULAR ACCOUNT OF SOME ERUPTIONS OF MOUNT ÆTNA, AND VESUVIUS, AND THE EARTHQUAKE AT LISBON.

. . . . Ah! whither now are fled
Those dreams of greatness? Those unsolid hopes
Of happiness? Those longings after fame?
Those restless cares? Those busy, bustling days?
Those gay-spent, festive nights? Those veering thoughts,
Lost between good and ill, that shar'd thy life?
All now are vanish'd!—VIRTUE sole survives,
Immortal, never-failing friend of man,
His guide to happiness on high. . . . . .

Thomson.

We come now to another set of philosophers, who entertain the opinion, that the earth's *heat* arises from the *conflict of elements* contained within her bosom.

First, With regard to the heat found in deep caverns, which rises above that of the surrounding atmosphere, they conceive that this may proceed from other causes than an actual fire in the center of our globe.

For only call to your recollection the principles composing the earth, its copious stores of sulphureous, metallic, bituminous, and other inflammable matters, which have only to meet with oxygenated water, when a decomposition takes place, liberating a vast quantity of free *caloric.*

In Section XII. we mentioned the sentiments of Mayow respecting the

cause of the Earth's heat, who was the first to attribute it to the conflict of its elements, and we shall soon have again occasion to notice his clear exposition of this sentiment, when we come to investigate the origin of hot-springs.

Lemery, who published a Practical Course of Chemistry the year after Mayow,* endeavours to account for subterraneous fires, from the following practical observations.

He mixed twenty-five pounds of powered *sulphur*, with an equal weight of *iron-filings*, and having kneaded the mixture together, by means of a little *water*, into the consistence of a paste, he put it into an iron pot, covered it with a cloth, and buried the whole a foot under ground.

In about eight or nine hours time, the earth swelled, grew warm, and cracked; hot sulphureous vapours were perceived, a flame which dilated the cracks was observed; the superincumbent earth was covered with a yellow and black powder; in short, a subterraneous fire, producing a volcano in miniature, was spontaneously lighted up from the reciprocal actions of sulphur, iron, and water.

The theory of this experiment is as follows. The *water* coming into contact with the *iron*, is decomposed. The *oxygen* of the *water* unites with the *iron*, and *hydrogen gas* (inflammable air) is given out, which dissolves a portion of *sulphur*, and becomes in consequence *sulphurated hydrogen gas*. This may be known by the fetid odour exhaled, as likewise by the flame emitted, which is more lively than that of sulphur, and less so than inflamed hydrogen air.

Mons. Beaumé, who observed this phenomenon, arising from an hundred pounds of iron-filings, and as much sulphur in powder, relates, that the flame produced rose to above a foot in height.†

That part of this experiment which relates to the production of flame, by the fermentation of iron-filings and sulphur when made into a paste, has been frequently repeated since the time of Lemery.

---

* Mayow published in 1674. Vide note * page 62.

† How *this air* next comes to be inflamed, is probably as follows. The *oxygen* of the water over and above what saturates the iron, goes to form with the sulphur, sulphuric, or *vitriolic acid*, and we know that this acid mixed with water, raises it to a high temperature, and, under the present circumstances, sufficient to inflame the sulphurated hydrogen gas.

"*I myself*," says a dignified and learned prelate,* "have made it more than once, but I have nothing material to add to his account, except that the flame, when the experiment is made in the open air, is of very short duration; and that the whole mass, after the extinction of the flame, continues at intervals, for a longer or shorter time, according to its quantity, to throw out sparks; and that a ladlefull of the ignited mass, being dropped down from a considerable height, descends like a shower of red-hot ashes, much resembling the paintings of the eruptions of Mount Vesuvius."

It has been observed, that large quantities of such materials are not requisite to make the experiment succeed, provided there be a due proportion of water: half a pound of steel-filings, half a pound of flowers of brimstone, and fourteen ounces of water, will, when well mixed, acquire heat enough to occasion the mass to take fire.†

But that heat and fire, continues the learned Bishop, should be generated from the spontaneous actions of *minerals* upon each other, is a phenomenon not altogether singular of its kind.

In minerals, as well as vegetables, a definite quantity of moisture is alone requisite to enable them to commence that intestine motion of their parts, and those decompositions, which are necessary for the production of flame.

---

* Dr. Watson, Bishop of Landaff, vide his *Chemical Essays*, in five volumes. In Vol. IV. we find the following very curious Preface: "Above two thousand copies of the former volumes of my Chemical Essays, have been sold in less than five years. I mention not this circumstance out of vanity, or as if I thought it contained any proof of their merit; but I produce it as a solid proof of the disposition of the public to become acquainted with chemical subjects, when they are treated in a popular way. This disposition has been long prevalent in foreign countries; it seems to be gaining ground in our own; and if I have endeavoured to contribute a little towards its establishment amongst us, I hope the utility of the design will plead my excuse with those who, in the severity of their judgments, may think that I have contributed to it more than, from the nature of my profession and situation, I ought to have done. When I was elected Professor of Divinity in 1771, I determined to abandon for ever the study of chemistry; and I did abandon it for several years: but the—*veteris vestigia flammæ*—still continued to delight me, and at length *seduced* me from my purpose. When I was made a Bishop in 1782, I again determined to quit my favourite pursuit: the Volume I now offer to the public is a *sad proof* of the imbecility of my resolution. I have on this day, however, offered a *sacrifice* to other people's notions, (certainly some Goths of the 18th century) I confess, rather than to my own opinion of *Episcopal Decorum*.—I have destroyed all my remaining chemical manuscripts.".. But it is yet to be hoped, that this Bishop will become a *sinner* again, and the public cannot fail to be benefited, as well as agreeably instructed; for as this most learned and elegant writer expresses himself elsewhere, "*The book of Nature and of Revelation, equally elevate our conceptions and incite our piety; they mutually illustrate each other; they have an* EQUAL *claim to our regard, for they are both written by the finger of* One eternal, incomprehensible God, to whom be glory, for ever and ever, amen."

† Vide *Sage's Miner*. Vol. I. p. 42.

Iron and sulphur would remain mixed together for ages without inflaming, if they were kept perfectly free from water, being incapable of taking fire, whilst they continued in that state.

But though it is certain, from the experiments above, that mixtures of iron and sulphur, when moistened with a proper quantity of water, will spontaneously take fire; yet the origin of subterraneous fires cannot, with any great degree of probability, be referred to the same principle, unless it can be shewn, that nature has combined together in large quantities iron and sulphur, and distributed the composition through various internal parts of the earth.

Now that this is really the case, we can have no doubt. There is perhaps no mineral more commonly met with, than that which is composed of sulphur and iron. It has been found not only upon the surface of the earth, but at the greatest depths below it, to which mines have been hitherto driven; not only in England or Italy, Europe or Asia, but in all parts of the world.

In England it goes by the name of copperas-stone, from its yellow colour; but its scientific appellation is pyrites, from πυρ, fire, a denomination expressive enough of the property this mineral has of spontaneously taking fire, when laid in heaps, and subjected to moisture.

For although Lemery was the first person who, by artificial mixtures of water, sulphur, and iron, produced heat, yet that natural mixtures of these substances would spontaneously take fire, was known long before he made his experiments.

Thus, to omit what is said by Pliny and the ancients, we are told upon good authority,* that in the year 1664, one Wilson, at Ealing, in Yorkshire, had piled up in a barn many cart-loads of the pyrites, or brass-lumps, as they were called by the colliers, for making of vitriol, or some secret purposes of his own, when the roof happening to be bad, the pyrites were wetted by the rains, and in this state began to smoke, and presently took fire, and burnt like red-hot coals.

The same accident was observed, above an hundred years ago, at Puddle Wharf in London, where heaps of coal which contained much of this pyrites took fire.

---

* Vide Power on the Microscope, who was contemporary with, and wrote a few years after, Hooke.

The same thing happened not long ago at Whitehaven, and in the neighbourhood of Halifax.

In the month of September, 1751, the Cliffs near Charmouth in Dorsetshire, took fire, in consequence of a heavy fall of rain after a hot and dry season, and they continued at intervals to emit flame for several years.

These cliffs consist of a dark-coloured bituminous loam, in which are imbedded large quantities of different kinds of the pyrites.

The same kind of flame has been frequently observed in the Cornish mines, and has often led to the discovery of the treasures in the earth; for wherever this has existed minerals, especially the pyrites, have universally been found.

There are some sorts of earth from which alum is made, which abound so much with pyrites that the proprietors of these works are forced to keep them constantly deluged with water, in order to keep them from firing.

But it seems useless to pursue this subject further; we have adduced proofs sufficient, that nature furnishes materials, which, under certain circumstances, may become the occasion of subterraneous fires.

The requisite circumstances are a proper quantity of the materials, and a proper proportion of water to moisten them.

A small quantity of the pyrites is sufficient to kindle a fire; water is almost every where found in such great plenty below the surface of the earth, that it constitutes one of the greatest impediments to our sinking pits to any great depth; and air, if it should be thought absolutely necessary to the spontaneous firing of the pyrites, may be conceived either to accompany the water in its dripping, or to descend into the innermost parts of the earth through fissures which are found upon its surface.

When a subterranean fire is once kindled, it may be supported for ages by other substances, as well as by those which first gave rise to it; thus if a quantity of the pyrites should take fire in a stratum of coal, or of shale, or any other substance strongly impregnated with bitumen, the fire might continue till the stratum was consumed.

There are some coaleries on fire now in Scotland, which were on fire in the time of Agricula (Pennant's Tour in Scot. p. 201). See an account of the coaleries on fire in Staffordshire, in Dr. Plott's Natural History of that

country; and of the substances sublimed from the burning coal-pits at Newcastle in Philosoph. Trans. for 1676."

In coal-mines, besides the choak-damp, fixed air, the production of open as of slow combustion, we find the fire-damp, inflammable gas*, the secret product of decomposed water, or of vegetable matters.

This may be breathed with impunity in a certain state of dilution with common air; but if a candle should chance to light it, the whole is instantly fired, and the supporter of the flame and his companions meet with an untimely and dreadful end.†

But not minerals alone, but other substances also generate a great degree of heat.

The warmth of putrescent dunghills, of the fermenting juices of vegetables, and, more than all, the spontaneous firing of hay is well known to every one.

Vegetable decomposition is also, as we shall hereafter shew, when we come to the subject of agriculture, greatly accelerated by the power of lime.

This alkaline substance, when it appears in the form of a grey white stone, is called quicklime.

This is most frequently met with in places adjacent to volcanoes.

When exposed to the action of the air, lime swells, breaks, and falls into powder; it then increases greatly in bulk, and is called lime slaked in air.

These changes are more remarkable, and take place more rapidly, when the air is in a humid state.

---

* This vapour is known in mines by the blue appearance of light, and is seen in flocculent balls floating above the pit. These assemble, and forming into one mass produce, when lighted, a terrific explosion. The miners hinder these natural balloons from assembling by driving them asunder with a fan elevated by a long stick, but when the quantity collected is great, the miners fall on their faces on the ground, and set fire to the lighter air above them. In certain mines replete with this air, as inflammable air is not kindled by a spark, and may be breathed with impunity, the miners continue to work, whilst a boy keeps turning a wheel which hits upon as many flints as there are opposing steels, and procures for them by this means a sufficiency of light.

† This happened to one of Lord Lonsdale's managers and some other people. As he was examining some parts of a mine, the boy was bid to hold the candle down and stoop, but, actuated by some sudden panic, he rose up, and an explosion taking place they were all burnt to death.

This dry slaking produces *heat*; and the dilatation is so considerable as to burst casks, or other wooden vessels in which lime may be contained.

These phænomena, says Fourcroy, are occasioned chiefly by the water contained in the atmosphere, and the force with which the lime tends to unite with it. For by heating lime which has been slaked with air in a retort, till it becomes red hot, water is obtained, and the lime returns to its original state.

Water acts very powerfully on quicklime. Pour a small quantity of that fluid on a quantity of lime, the water is instantly absorbed, and the mass of lime appears as dry as before; but it soon bursts and breaks into pieces.

The *heat* excited in it by this operation is so strong, as to produce a remarkable hissing noise: the water is reduced to vapour of a peculiar smell, which communicates a green colour to a paper tinged with syrup of violets. The lime soon falls down to a powder; and the heat, motion, and smoke gradually disappear. If the process be performed at night, in a place perfectly dark, a great many luminous points are observable all over the surface of the lime.

This remarkable phænomenon did not escape the active mind of Mayow, who, in Chapter XIV. of his elaborate work, treating on the *heat* from quicklime and the union of different salts, remarks, that this substance is a compound of two contrary principles, an acid and an alkali, and that the nitro-aerial-particles (oxygen) is so inherent in the acid, and in so dry a state, that they are inert, and as it were fixed; but when water pervades these two bodies, the laws of affinity then act, and these two opposite natures combine, and give out the heat which was before in a dormant state.

May we not rather attribute this process to the air in the interstices of of the water, and in part to a decomposition of the water; or does our present knowledge of the nature of lime give a sufficient solution of this question?

Seeing then that there are great chemical actions going on in the bowels of the earth, and observing the slow circulation of air, the heat consequently liberated from these natural processes becomes stagnant, and accounts readily for that uniformity observed at certain depths.

For, the earth possesses a wonderfully retentive power, only parting with its heat in the most gradual manner, which is proved by the following experiments of the illustrious Dr. Hales.

EXPERIMENT I.

This philosopher having observed that the air was at 88° of Farhenheit's thermometer, August 1, 1724, found that the earth at its surface had precisely the same heat; the thermometer being then plunged two inches deep into the ground, stood at 85°; another at sixteen inches, at 70°; and another at twenty-four inches, at 68°.

The two last preserved the same temperature day and night to the end of the month, and then only fell to 63°.

EXPERIMENT II.

On the 26th of October, a thermometer exposed to the air by the same philosopher stood at 35° 5; but one sunk two inches in the earth was found to rise to 43° 85, another sunk sixteen inches reached 48° 8, and one at twenty-four inches stood at 50°.

EXPERIMENT III.

He even found, that between the first and second of November, when the external air was at 27°, a thermometer at twenty-four inches depth stood at 43° 8.

EXPERIMENT IV.

When, in the coldest days of the winter 1724, the frost was so intense as to freeze the surface of stagnant water near an inch thick, Dr. Hales remarked, that his thermometer, which was exposed to the open air, was four degrees below the freezing point; and he found that placed two inches under ground it was four degrees above the freezing point; the third, fourth, and fifth thermometers were proportionably higher, as they were deeper in the ground, to the sixth thermometer, which being two feet under ground the spirit was as high as ten degrees above the freezing point.

This is shewn also by observing the progress of a thaw with snow on the ground, or an hoar-frost, which is dissolved on the surface of the ground, when it remains on the tiles, and on the tops of walls.

The preservation of gooseberries in bottles buried deep in the earth is a familiar example of this fact.

CONCLUSION FROM THESE EXPERIMENTS.

Hence Dr. Hales concludes, that the earth parts with its heat with difficulty to the air, and will retain its natural temperature, which is between 40° and 50°, at a very small depth beneath the surface, even when the air is below the freezing point, which is an admirable contrivance of Nature for the preservation of her offspring.

SECONDLY, with regard to the equal temperature of the *warm springs* found in many parts of the earth, the opinion that these arise from a subterranean fire did not escape the sagacious mind of the philosopher of the last century.

"Had the warmth of the Bath waters," says MAYOW, "proceeded, as some have supposed, from an actual subterranean fire, this in all probability had been extinguished by the waters themselves,* and this phænomenon had long since ceased."

"Hence it is more probable to suppose, that the superior temperature of these waters arises from a fermentation excited in the body of the earth itself."

---

* In Ovid the *flood* is brought in, after the *battle of the giants,* which is hyperbolic of the eruption of burning mountains, which had devasted the earth, and threatened heaven itself, as a means to *quench these fires,* and reduce this torn and confounded face of things into some better form and order. And that Jupiter might be vindicated from the charge of cruelty towards the creatures of his hands, the men of those times (the iron age) are represented as extremely wicked, and the preservation of *Deucalion* and *Pyrrha* proves sufficiently his regard for mortals, and his wish to reward virtue.

> Nunc mihi qua totum Nereus corcumsonat orbem
> Perdendum est mortale genus.———
> Cuncta prius tentanda, sed immedicabile vulnus
> Ense recidendum est, ne pars sincera trahatur.

" Indeed, it must be allowed, that sometimes whole mountains are composed nearly wholly of vitriolated or aluminous marchasites."

" Also that the rains sink through the spongy substance of the earth, and finding a proper channel, constitute springs, containing within their pores the *nitro-aerial particles*,* as essential to the production of fire, which the air-pump demonstrates."

" For if rain or other water be put into a glass, and the air extracted from this by suction, immediately are seen numerous bubbles of air rushing from the body of the water."

" We may now remark, that if these *salino-sulphureous* mountains be humected with *water*, an effervescence will take place, and *heat* be induced."

" For if marchasites, or any salino-sulphureous glebe, mixed with either vitriol, or any similar salt, be exposed abroad to an humid atmosphere, or the rains of heaven, these in a short time will in a remarkable way ferment. Thus also, if any *salino-sulphureous mineral*, recently dug up, be moistened with *rain*, this in a short space of time will ferment and give out *heat*."

" In confirmation of this doctrine," continues MAYOW, " the high hills by which the wells of Bath are surrounded, abound with *marchasites*, and these waters shew an impregnation of the nature of an *acid*, for if any alkali

---

* The *nitro-aerial particles*, or *oxygen*, may arise also in part from *the decomposition of the mineral acids*. If we mix two parts of *spirits of wine* with one of *fresh fuming spirits of nitre* (the oxygenated nitric acid) the mixture will remain cold for near ten minutes, and it will after that time begin to acquire some degree of heat, till at length it will boil with great violence for a considerable length of time.

In like manner, by mixing together equal bulks of *strong spirit of vitriol* (the sulphuric acid) with *water*, we can raise from these bodies, previously cold, a degree of heat nearly equal to what boiling water exhibits.

If the *fuming acid of nitre* (the nitric acid) be mixed with *oil of turpentine*, let it be in the depth of winter, and when these two fluids are severally colder than ice, yet you will see them, to the utter astonishment of those not much versed in chemical phænomena, instantaneously catch fire, and kindle a powerful flame. A pint of each being employed will raise a column of fire and smoke more than twenty feet in height.

In the Philosophical Transactions for 1699, we have a table expressing at one view, the effect which the *nitrous acid* has upon a variety of other oils, as well as that of turpentine, and we find there enumerated twelve sorts of oils, which, when mixed with the *acid of nitre* (the nitrous acid) effervesced and exploded with a flame.

In addition to the information contained in this table, we are indebted to the French chemists for a variety of interesting memoirs on the inflammation of oils, both by the simple nitrous acid, and by that acid, when mixed with the vitriolic acid.

Musschenbroeck has related above 200 experiments, illustrating the alteration of the temperature arising from the mixture of different substances with water, spirits of wine, and the mineral and vegetable acids.

be mixed with these waters, a precipitation soon is excited, and they become turbid, and then white."

From this cause these unite badly with soap, since the acid of these waters conflicts with the alkali of the soap, and so blunts its virtues, that the sulphureous and oily part of the soap, now liberated from the fixed salt, cannot mix with the water, but swims on its surface."

Thirdly, respecting the cause of *earthquakes*, as proceeding from some inward commotion of the central parts of the earth, the cessation of many volcanos, which may be said to be burnt out;* and the less frequency of these occurrences in our times, is a strong argument against this sentiment.

A better explanation of these wonderful *phænomena* seems to me given

---

* In Spallanzani's Travels in the Two Sicilies there are numerous examples of this fact. Chap. xvi. Observations on Lipari. 'I ascended,' says this philosophic traveller, 'to the summit of Monto San Angelo, situated to the north of the city of Lipari, this being the highest mountain of the Island.

The top, far from having a conical figure, such as is that of Stromboli, and in a certain manner Vulcano, was composed of groups of broken mountains, confusedly heaped together, which gave it a most irregular appearance.

It is evident that the *volcanic fires have raged in many places*, and that, from their too great proximity to each other, they have not been able to form those distinct cones which are so observable in Vesuvius and on Ætna.

But the matter ejected by the superior volcanos, pouring upon those which issued from the lower, have produced in every part confusion and disorder to be observed there.

From the summit of Ætna we may discover a multitude of subjacent craters, well characterised; but from that of San Angelo I could not perceive one. There are, indeed, many openings and hollows to be seen, which *once* were fiery mouths; but none of these have at present the figure of an inverted funnel, being filled up, or destroyed by time.

That fires existed in the time of Aristotle is certain. Και το εν τη Λιπάρα δε πυρ φανερον και φλογωδες, ου μεν ἡμερας, αλλα νυκτος μονον και εσθαι λεγεται. Since which time there is no mention of any fires appearing in that island.'

Speaking of Felicuda and Alicuda, two islands to the westward of Lepari, Chapter xvii, he says, 'both shewed vestiges of their *primitive crater*, that is, of that which gave birth to each respective island.

The volcanic materials were numerous, yet were there no signs of any activity in these islands to be discovered, except a warm spring in Felicuda, which issues from a rock on the northern side of these islands.'

I shall here collect the observations which have been left us by the ancients relative to these two islands, as these are extremely brief, and few.

Aristotle, speaking of Phenicura, as it was then styled, says, 'it received its name from its abounding in palms,' φοινιξ, φοινικος, being the Greek appellation of that tree.'

Ericusa, as it was then called, was derived, according to Strabo, from heath, 'erica,' which was abundant there.

But neither of the above writers, or any other of the ancient authors, mention any fires as existing in these two islands, although they relate that Lipari, Stromboli, and Vulcano, threw out flames, as these, it is more than probable, were *wholly extinguished* in those days.'

by the learned and ingenious Dr. Hook, who, after stating his objections to the opinion entertained by some, that the centre of the earth was liquid fire,*

---

* The Greeks entertained the notion that *hell,* or the place for the manes of departed people, was in the centre of the earth, and that there were certain passages leading thither, as the river Lethe, and the Acherusian cave. These were long roads, hence their custom of putting pieces of money into the mouths of the dead to pay their journey. At Hermione the way was shorter, and hence the omission there of the custom of putting money into the mouths of the departed.

Milton gives us a fine poetic description of the rivers which descend into, and mingle with the flames of hell—

———— They bend
Four ways their flying march along the banks
Of four infernal rivers that disgorge
Into the *burning lake* their baleful stream:
Abhorred Styx, the flood of deadly hate;
Sad Aceron, of sorrow black and deep;
Cocytus, named from lamentation loud,
Heard on the rueful stream; fierce Phlegethon,
Whose waves of torrent fire inflame with rage;
Far off from those a slow and silent stream,
Lethe, the river of oblivion, rolls, &c.

The Greeks fancied the *umbra,* or *ghost,* hovered near the place where the death happened, whilst the *spirit, spiritus,* went to heaven. This idea is expressed in the following lines attributed to Ovid.

Bis duo sunt homini: Manes, Caro, Spiritus, Umbra,
Quatuor ista loci bis duo suscipient.
Terra tegit *Carnem,* tumulum circumvolat *Umbra,*
Orcus habet *Manes, Spiritus* astra petit.

Thus Homer:

—— The fates suppress'd his lab'ring breast,
And his eyes stiffen at the hand of death;
To the realms above the *spirit* wings its way,
The manly *body* stops, a load of clay,
And plaintive glides along the dreary coast,
The naked—wand'ring—melancholy—*ghost.*

The Jews seem to have entertained the same notion of *hell* as the Greeks, and hence our Saviour, adapting his discourse to their conceptions, gives the parable of Dives and Lazarus.—The word *infernal* comes from *inferus, below;* and on the stage these are always represented with torches in their hands, and involved in flames.—But there is nothing in natural or revealed religion to authorise such a conception. God is every where represented in Scripture in his true character, as the God of "Love" and "Mercy." "He wills, that all mankind should be saved." 2 Tim. ii. 4. "In my Father's house there are many mansions," says our Lord. S. John xiv. 2. Is it not then more than probable that those innumerable stars we see above us are replete with *inhabitants,* and that we pass from one star, or world, to another star, or world, either *approaching* towards, or *receding* from that Being (the plenitude of happiness, the cause of all things, whom we in this world behold as through a glass darkly; i. e. faintly conceiving the idea by the contemplation of the works of creation and redemption), according to our spent lives, and that every *punishment* inflicted on man is founded in *justice* tempered with *mercy?* Can there be any conception more noble than this? An infinity of stars, and each stored with an infinite number of differently created beings enjoying different degrees of happiness! If there are 10,000 insects, and 300 animals, reckoning the kinds in this world of sorrow, and delight, how vast the conception of millions of worlds and myriads of different beings, and each distinct and perfect as a whole, yet making but a link in the chain of created beings! Even the sight of the splendour of the heavenly bodies is the grandest spectacle in nature.

When the moon, refulgent lamp of night,
O'er heav'n's clear azure spreads her sacred light,
When not a breath disturbs the deep serene,
And not a cloud o'ercasts the solemn scene——
Around her throne the vivid planets roll,
And stars unnumber'd gild the glowing pole.
Then shine the vales, the rocks in prospect rise,
And floods of glory burst from all the skies.

HOMER.

That we have *pre-existed* is supported both by revelation as well as reason, for when the Jews brought the boy born blind to CHRIST, asking " for whose sin did this misfortune happen, whether as an affliction to his parents, or for his own sin"—" Neither," says our blessed LORD, " was it for his own sins, (mark he was *born* blind) nor for those of his parents; but (in this particular instance) that the power of GOD might be made manifest." And " Christ touched the eyes of the boy, and he that was blind immediately saw." So if we consult reason, we cannot fail to observe some children exhibiting the most perverse disposition, even in their very cradle, and others again as good; and there is no life, however esteemed here as prosperous, but has its afflictions, which shews us to be in the state of punishment, or purification. The doctrine, says the celebrated Ramsay, of the creation of a new soul at every birth, and this pure innocent spirit to be incarcerated in a weak body, subject to innumerable accidents, and diseases, and so actuating the spirit, as to render it afterwards liable to the torment of an eternal fire, and the reason of GOD acting so, because of the sin of one man, who lived 4000 years ago, and with whom we have no more connexion than with Nero, or Caligula, is contrary to every notion we should entertain of GOD, and of his attributes. He is truly " the God of Love," and the whole relation of Moses is therefore figurative. The fall of Adam is only the *type* of the true condition of all of us here. He was surrounded by objects of creation the most agreeable. A consort was added to complete his paradisiacal felicity. In this blessed state he was subject to commandment, and the story of the apple is only *allegorical* of the ease there was in obedience, " My yoke is easy, and my burthen is light." But possessing *free-will,* for so it pleased God, man abused his nature, and was driven out of paradise; and whether he passed from one star to another star, or the abode *was altered,* is immaterial to our argument. The poet may be allowed to manage it as he pleases.—How fine is his account of this matter.

——— He scrupled not to eat
Against his better knowledge, not deceiv'd,
But fondly overcome with female charm,——
Earth trembled from her entrails as again
In pangs, and Nature gave a second groan;
Sky lour'd, and muttering thunder, some sad drops
Wept, at the completing of the mortal sin
Original.—Then to diverse angels GOD gave charge
As sorted best with present things. The sun
Had first his precept so to move, so shine
As might affect the earth with cold and heat
Scarce tolerable, and from the north to call
Decrepit winter, from the south to bring
Solstitial summer's heat. To the blank moon
Her office they prescrib'd, to th' other five
Their planetary motions and aspects
In sextile, square, and trine, and opposite
Of noxious efficacy, and when to join
In synod unbenign; and taught the fix'd
Their influence malignant when to shower,
Which of them rising with the sun, or falling,

Should prove tempestuous: to the winds they set
Their corners, when with bluster to confound
Sea, air, and shore; the thunder when to roll
With terror through the dark aerial hall.
Some say HE bid his angels turn ascanse
The poles of earth twice ten degrees and more
From the sun's axle. They with labour push'd
Oblique the centric globe; some say the sun
Was bid turn reins from th' equinoxial road
Like distant breadth to Taurus with the seven
Atlantic Sisters, and the Spartan Twins
Up to the Tropic Crab; thence down amain
By Leo and the Virgin, and the Scales,
As deep as Capricorn, to bring in change
Of seasons to each clime; *else had the spring*
Perpetual smil'd on earth with vernant flowers,
Equal in days and nights, except to those
Beyond the polar circles; to them day
Had unbenighted shone, while the low sun,
To recompense his distance, in their sight
Had rounded still th' horizon, and not known
Or east or west, which had forbid the snow
From cold Estotiland, and south as far
Beneath Magellan. At that tasted fruit
The sun, as from Thyestean banquet, turn'd
His course intended; else how had the world
Inhabited, though sinless, more than now,
Avoided pinching cold and scorching heat?
These changes in the Heav'ns, though slow, produc'd
Like change on sea and land, sideral blast,
Vapour, and mist, and exhalation hot,
Corrupt and pestilent: now from the north
Of Norumbega, and the Samoed shore,
Bursting their brazen dungeon, arm'd with ice,
And snow, and hail, and stormy gust, and flaw,
Boreas, and Cæcias, and Argestes loud,
And Thrascias rend the woods, and seas upturn;
With adverse blast upturns them from the south
Notus and Afer; black with thund'rous clouds,
From Serraliona; thwart of these as fierce
Forth rush the Levant and the Ponent winds,
Eurus and Zephyr, with their lateral noise,
Sirocco and Lebecchio. Thus began
Outrage from lifeless things; but Discord first,
Daughter of Sin, among the irrational,
Death introduc'd through fierce antipathy:
Beast now with beast 'gan war, and fowl with fowl,
And fish with fish; to graze the herb all leaving,
Devour'd each other; nor stood much in awe
Of man, but fled him, or with count'nance grim
Glar'd on him passing. These were from without
The growing miseries which Adam saw
Already in part, though hid in gloomiest shade,

To sorrow abandoned, but worse felt within,
And in a troubled sea of passion tost,
Thus to disburden sought with sad complaint.
" O miserable of happy! is this the end
Of this new glorious world, and me so late
The glory of that glory, who now become
Accurs'd of blessed, hide me from the face
Of God, whom to behold was then my height
Of happiness!———
O unexpected stroke, worse than of death!
Must I thus leave thee, PARADISE? thus leave
Thee, native soil, these happy walks and shades,
Fit haunt of gods? where I had hope to spend,
Quiet, though sad, the respite of that day
That must be mortal to us both? O *flowers,*
That never will in other climate grow,
My early visitation, and my last
At even, which I bred up with tender hand
From the first opening bud, and gave ye names,
Who now shall rear ye to the sun, or rank
Your tribes, and water from th' ambrosial fount?
Thee lastly, nuptial bow'r, by me adorn'd
With what to sight or smell was sweet, from thee
How shall I part, and whither wander down
Into a *lower world,* to this obscure
And wild? how shall I breathe in other air
Less pure, accustom'd to immortal fruits?
O miserable of Mankind, to what fall
Degraded, to what wretched state reserv'd!
Better end here unborn. Why is life given
To be thus wrested from us? rather why
Obtruded on us thus? who, if we knew
What we receive, would either not accept
Life offer'd, or soon beg to lay it down,
Glad to be so dismiss'd in peace. Can thus
Th' image of God, in man created once
So goodly and erect, though faulty since,
To such unsightly sufferings be debas'd
Under inhuman pains? Why should not man,
Retaining still divine similitude
In part, from such deformities be free,
And for his Maker's image sake exempt?"
"Their Maker's image," answer'd MICHAEL, "then
Forsook them, when themselves they vilify'd
To serve ungovern'd appetite, and took
His image whom they serv'd, a brutish vice,
Inductive mainly to the sin of Eve.
Therefore so abject is their punishment,
Disfiguring not God's likeness, but their own,
Or of his likeness, by themselves defac'd,
While they pervert pure Nature's healthful rules
To loathsome sickness, worthily, since they
God's image did not reverence in themselves.

" I yield it just," said Adam, and submit.
But is there yet no other way, besides
These painful passages, how we may come
To death, and mix with our connatural dust?"
" There is," said Michael, " if thou well observe
The rule of not too much, by temp'rance taught,
In what thou eat'st and drink'st, seeking from thence
Due nourishment, not gluttonous delight,
Till many years over thy head return:
So may'st thou live, till like fruit thou drop
Into thy mother's lap, or be with ease
Gather'd, not harshly pluck'd, for death mature:
This is old age; but *then* thou must outlive
Thy youth, thy strength, thy beauty, which will change
To wither'd, weak, and gray; thy senses then
Obtuse, all taste of pleasure must forego
To what thou hast; and for the air of youth,
Hopeful and cheerful, in thy blood shall reign
A melancholy damp of cold and dry
To weigh thy spirits down, and last consume
The balm of life." To whom our Ancestor:
" Henceforth I fly not death, nor would prolong
Life much, bent rather how I may be quit
Fairest and easiest of this cumbrous charge,
Which I must keep till my appointed day
Of rendering up, and patiently attend
My dissolution." Michael reply'd:
" Nor love thy life, nor hate: but what thou liv'st
Live well; how long or short permit to Heav'n."

Michael then shews, that God tempers his *judgments* with *mercy,* and points out to Adam the promise of *redemption* of mankind through Christ. For as there is a chain of exalted beings, cherubs, cherubims, and seraphims, so at the summit is *Christ,* so exalted in nature as to be equal to God, and being a direct emanation from that inconceivable spirit, the nearest approximation to the Godhead, therefore one part of the holy Trinity. With the utmost condescension this emanation, whose act it was to produce our globe amidst applauding angels, is embodied in a human form, reveals the will of God, and satisfies infinite justice, by an atonement for the sins of the whole world, and thus overcomes death. " Oh grave, where is now thy victory." How comforting the words, " I am the resurrection and the life!" In the divine volume we are also informed of administering angels. We are objects of their special concern. They first receive our departed spirits, when we shake off the mortal coil. How friendly the office to lessen our astonishment at the opening splendour of a *new world!* Vide Petitpierre on Divine Goodness, proving the *Universal Redemption* as a *Scriptural Doctrine.*

That there were no *infernal regions* and *eternity of punishments,* was also conjectured by the wisest among the ancients. Lucretius, Lib. III. 991.

——— The dismal tales that poets tell
Are verified on earth, and not in hell.
No Tityus, torn by vultures, lies in hell,
Nor could the lobes of his small liver swell
To that prodigious mass, for their eternal meal:
But he's the Tityus, who, by love oppress'd,
Or tyrant passion preying on his breast,
And ever anxious thoughts, is robb'd of rest.
The Sisiphus is he, whom noise and strife
Seduce from all the soft retreats of life,

To vex the government, disturb the laws;
Drunk with the fumes of ignorant applause,
He courts the idle crowd to make him great,
And sweats, and toils in vain, to mount the sov'reign seat;
For still to aim at pow'r, and still to fail,
Ever to strive, and never to prevail,
What is it but, in Reason's true account,
To heave the stone against the rising mount?

The idea of subterranean fires, and the spirits of the damned inhabiting them, arose from that superstition, which *personified* all *extraordinary natural powers*. Hence the fable of the giants, from γη, the earth, and γεινομαι, to spring from, born of the earth: these are represented as in that part of Tartarus, or Hell, where the depth in the earth is twice as great as the height extends to the throne of Heaven.

——— Tum Tartarus ipse
Bis patet in præceps tantum, tenditque sub umbras,
Quantus ad ætherium Cœli suspectus Olympum,
Hic genus antiquum terræ, Titania pubes
Fulmine dejecti, fundo volvuntur in imo.

VIRG.

Hence the description of Æneas's terror when he was shewn,

Et centumgemitus Briareus, et bellua Lernæ.
Horrendum stridens, flammisque armata chimæra.

All which is descriptive of burning mountains, and this is more fully verified by Jupiter's putting over these giants the mountains of Peleon, and Ossa, in order to keep them under.

The fable of the rape of Proserpine, by Pluto, fully verifies this supposition. She is described as the offspring of Ceres, and is plainly delineated, as a city situate where the Lake Pergusa is at present, and the country around is filled with cascades, woods, and flowers, just such as Proserpine is said to have been innocently sporting in, when Pluto on a sudden seized upon her, and carried her to his dreary realms. In this metamorphosis, or fable, the rebellious giant Typhæus is represented as covered by the Island Tinacria, Sicily; and such was his violent struggle to get liberated, that Dis or Pluto is fearful lest the vault of earth covering his own residence should be broken up,

——— Et Rex pavet ipse silentum.

This brought the God of Terrors up, who falls in love with the beauty of Proserpine, that is, becomes enamoured of the fair town of Pegusa, and it is swallowed up, and the remainder of the story is taken up with a description of the devastation occasioned by this earthquake, by representing the pursuit of Ceres after her daughter, over the earth, and her return to Sicily, shewing how Sicily was again rendered fruitful and abundant in corn.

Milton's rebellion of the angels is taken from the Gigantomachia of the ancients.

Forthwith (behold the excellence, the pow'r,
Which God hath in his mighty angels plac'd)
Their arms away they threw, and to the hills
(For earth hath this variety from heav'n
Of pleasure situate in hill and dale)
Light as the lightning glimpse they ran, they flew;
From their foundations loos'ning to and fro,
They pluck'd the seated hills, with all their load,
Rocks, waters, woods, and by the shaggy tops
Up-lifting bore them in their hands. Amaze,
And fright, and terror seiz'd the rebel host,
When coming towards them so dread they saw
The bottom of the mountains upward turn'd;

Till on those cursed engines triple-row
They saw them whelm'd, and all their confidence
Under the weight of mountains buried deep;
Themselves invaded next, and on their heads
Main promontories flung, which in the air
Came shadowing, and oppress'd whole legions arm'd;
Their armour help'd their harm, crush'd in and bruis'd
Into their substance pent, which wrought them pain
Implacable, and many a dolorous groan,
Long struggling underneath, ere they could wind
Out of such pris'n, though spirits of purest light,
Purest at first, now *gross* by sinning grown.
The rest in imitation to like arms
Betook them, and the neighb'ring hills uptore;
So hills amid the air encounter'd hills
Hurl'd to and fro with jaculation dire,
That under ground they fought in dismal shade;
Infernal noise; war seem'd a civil game
To this uproar: horrid confusion heap'd
Upon confusion rose. And now all heav'n
Had gone to wreck, with ruin overspread,
Had not th' Almighty FATHER, where HE sits
Shrin'd in his sanctuary of heav'n secure,
Consulting on the sum of things, foreseen
This tumult, and permitted all, advis'd;
That his great purpose HE might so fulfil,
To honour his anointed SON aveng'd
Upon his enemies.——
HE on his impious foes right onward drove,
Gloomy as night; under his burning wheels
The stedfast empyrean shook throughout,
All but the throne itself of GOD. Full soon
Among them HE arriv'd, in his right hand
Grasping ten thousand thunders, which he sent
Before him, such as in their souls infix'd
Plagues: they astonish'd, all resistance lost,
All courage; down their idle weapons dropt:
O'er shields, and helms, and helmed heads he rode
Of thrones and mighty seraphim prostrate,
That wish'd the mountains now might be again
Thrown on them, as a shelter from his ire.
Nor less on either side tempestuous fell
His arrows, from the fourfold-visag'd Four
Distinct with eyes, and from the living wheels
Distinct alike with multitude of eyes;
One spirit in them rul'd, and every eye
Glar'd lightning, and shot forth pernicious fire
Among the accurs'd, that wither'd all their strength,
And of their wonted vigour left them drain'd,
Exhausted, spiritless, afflicted, fall'n.
Yet half his strength he put not forth, but check'd
His thunder in mid volley; for he meant
Not to destroy, but root them out of heav'n;
The overthrown he rais'd, and as a herd
Of goats or tim'rous flock together throng'd,

or, as other learned men have supposed, an immense cavern of water,*

Drove them before him thunder-struck, pursu'd
With terrors and with furies to the bounds
And crystal wall of heav'n; which op'ning wide,
Roll'd inward, and a spacious gap disclos'd
Into the wasteful deep: the monstrous sight
Struck them with horror backward, but far worse
Urg'd them behind; headlong themselves they threw
Down from the verge of heav'n; and dreadful wrath
Burnt after them to the bottomless pit.
Hell heard th' unsufferable noise, Hell saw
Heav'n ruining from Heav'n, and would have fled
Affrighted; but strict fate had cast too deep
Her dark foundations, and too fast had bound.
Nine days they fell; confounded Chaos roar'd,
And felt tenfold confusion in their fall
Through his wild anarchy, so huge a rout
Incumber'd him with ruin: Hell at last
Yawning receiv'd them whole, and on them clos'd;
Hell, their fit habitation, fraught with fire
Unquenchable, the house of woe and pain.
Disburden'd Heav'n rejoic'd, and soon repair'd
Her mural breach, returning whence it roll'd.

* Milton represents the centre as a chaos,

Before their eyes in sudden view appear
The secrets of the centre, a deep and dark
Illimitable ocean, without bound,
Without dimension, whose length, breadth, and height,
And time, and place, are lost; where eldest Night
And Chaos, ancestors of Nature, hold
Eternal anarchy, amidst the noise
Of endless wars, and by confusion stand.

But Descartes, and others, have supposed this centre to be a hollow filled with water. Some have in this way interpreted the words of Moses, who, speaking of the deluge, mentions 'that God broke up the fountains of the great deep.' In the history of every kingdom of the world, there are found traditions of this extensive or universal *deluge*, and Whiston has supposed it to have arisen from a comet, which was conceived to be the sun in those distant days, which was supposed to have wandered from its course, and hence the story of Deucalion and Pyrrha, and of Phaeton. This fiery meteor, or comet, proceeding from pole to pole, melted the ice which occupies or caps the two hemispheres, and thus produced this universal deluge. We should, however, first remark, that the effusion of but part of the ices of the Cordeliers, in Peru, is sufficient to produce an annual overflow of the Amazons, of the Oroonoko, and of several other great rivers of the new world, and to inundate a considerable part of the Brazils, of Guiana, and the terra firma of America; and that in like manner the melting of part of the snows on the mountains of the Moon in Africa, occasions every year the inundations of Senegal, the overflowing of the Nile, and that similar effects are annually produced in a considerable part of southern Asia, in the kingdoms of Bengal, Siam, Pegou, Cochin-China, and in the districts watered by the Tigris, Euphrates, and many other rivers of Asia, which have their sources in chains of mountains perpetually covered with ice, namely, Taurus and Imaus. Who then can doubt, but that the total fusion of the ices of the poles, would be sufficient to inundate the whole globe, without having recourse to the hollow of the earth, being replete with waters? Only paint to yourself this catastrophe, if the mind can stretch to the conception,

which gives us so sublime an idea of the power of the ALMIGHTY, equally great as the Creator, and as the dissolver of his works; and you would behold torrents of thawed ice and snow, issuing from all the flood-gates of the poles, from the Straits of the Sea of Anadir, from the Gulphs of Kamschatka, from the Baltic Sea, from the Straits of Stagat, from the unknown sluices of Spitzbergen, and Greenland, from Hudson's Bay, and from parts which can have no name, and these issuing in two opposite directions, tearing up all before them, then were the elephants of Africa tossed among the firs of Siberia, whose bones are found to this day, and the shells of the sea-shore carried to the tops of mountains, vestiges of which are every where to be seen. In this confusion of elements every thing was mingled, cities, palaces, majestic pyramids, triumphal arches; and the vapour arising from the comet, acting on these new waters, caused a perfect mist, and the rain of forty days and forty nights; and it was one hundred and fifty days before these waters returned to their proper channel and were again frozen at the poles. In employing a comet the ALMIGHTY acted by second causes, but HE chose to make a *miraculous* preservation of one family, and one genus of each kind of animal and plant; and who shall put limits to his power, and say, that this was impossible? or can we suppose, that this deluge, of which every history has some record, was *very extensive*, but *not universal*, and that by means of *navigation* these desolated parts became again to be inhabited, and resume its wonted beauty, and accept of the *figurative*, rather than the *literal interpretation of Scripture*, in what relates to an *historical representation?* 'The fountains of the great deep were broken up,' according to this interpretation, would relate to the fissures and cracks produced on the earth by the piercing heat of the fiery comet.—

> Tum facta est Libye raptis humoribus æstu
> Arida, tum Nymphæ passis, fontesque lacusque
> Diflevere comis—v. 237.
> Dissilit omne solum penetratque in Tartara rimis
> Lumen et infernum terret cum conjuge regem.
> Et mare contrahitur, siccæque est campus arenæ,
> Quod modo pontus erat; quosque altum texerat æquor
> Existunt montes, et sparsas Cycladas augent.—Ovid, v. 260.

That the deluge arose from the overflowings of the sea may be drawn from the book of Job, (chap. xxxviii. ver. 8.) which was written by Moses as a moral tale, or parable, to inspire the children of Israel with patience and confidence in GOD.—Under his heavy affliction he asks, "Who appointed gates to the SEA, and *shut it up again,* after it had *inundated the earth,* rushing, as from the womb of its mother?"—This is mentioned in enumeration of the other wonderful works of GOD, illustrative of his *judgments* and *mercy*.—Such contemplations to some may appear gloomy, but, on the contrary, they serve to elevate the mind, and raise it from low and vulgar conceptions, and to make us look forward with fond hope to another earth, where there are no *mines* ready to explode, under our very footsteps, or *waters* to burst their bounds, and overwhelm us in an instant. Can there be any thoughts higher or more consoling than these we are recording? That successive generations of men have arisen to possess the earth. By turns they have passed away, and gone into regions unknown. Us HE hath raised up, to occupy their room. We too shall shortly disappear. But human existence never perishes. Life only changes its form, and is renewed. Creation is ever filling, but never full. As a shepherd leads his flock from one pasture to another, so the great CREATOR leads forth the souls which he has made, into new and prepared abodes of life. They go from this earth to a new earth, and new heavens; and still they remove, only from one province of the divine dominion to another. Amidst all these changes of nature, the great Ruler HIMSELF remains, "*without variableness or shadow of turning*." To HIM, these successive revolutions of being are but "*as yesterday*." From HIS eternal throne, HE beholds worlds rising and passing away; measures out, to the creatures who inhabit them, powers and faculties suited to their state; and distributes among them rewards and punishments, proportioned to their actions.——What an astonishing view do such meditations afford of the kingdom of GOD; infinite in its extent; everlasting in its duration; exhibiting, in every period, the reign of perfect righteousness and wisdom! "*Who by searching can find out* GOD? *who can find out* the ALMIGHTY *to perfection? Great and marvellous are all thy works, Lord God* ALMIGHTY! *Just and true are all thy ways, thou* KING OF SAINTS!"

relates the following opinion, arising from the consideration of certain chemical phænomena.

" Being," says this philosopher, " but a mile distant from the powder-mills of Hackney, when they blew up, the great noise and shock it occasioned brought to my recollection what had lately happened at the Isle of MODUNDA, which it seems is all an uninhabited rock, and was split by an earthquake, and a part of it tumbled down, and sunk into the sea, upon which occasion there was heard first a prodigious *noise* like the roaring of *cannon**, attended with a cloud of smoak."

---

* The famous Bishop BERKLEY gives us an account of an eruption of mount VESUVIUS, in which he paints these " pleasing dreadful scenes" with all the ability of a great master. I reached, says he, with much difficulty in the year 1717, the middle of April, the top of mount VESUVIUS, in which I saw a vast aperture full of smoke, which hindered me from seeing its depth and figure. I heard within that horrid gulf certain extraordinary sounds, which seemed to proceed from the bowels of the mountain, a sort of murmuring, sighing, dashing sound, and between whiles a noise like that of thunder or cannon, with a clattering like that of tiles falling from the tops of houses into the streets. Sometimes, as the wind changed, the smoke grew thinner, discovering a very ruddy flame, and the circumference of the crater streaked with red and several shades of yellow. After an hour's stay, the smoke being moved by the wind, gave us short and partial prospects of the great hollow; in the flat bottom of which I could discern two furnaces almost contiguous; that on the left seeming about three yards over, glowing with ruddy flame, and throwing up red-hot stones, with an *hideous noise*, which, as they fell back, caused the clattering already taken notice of. May 8, in the morning, I ascended the top of Vesuvius a second time, and found a different face of things. The smoke ascending upright, gave a full prospect of the crater, which, as I could judge, was about a mile in circumference, and an hundred yards deep. A conical mount had been formed since my last visit, in the middle of the bottom, which I could see was made by the stones, thrown up and fallen back again into the crater. In this new hill remained the two furnaces already mentioned. The one was seen to throw up every three or four minutes, with a *dreadful sound*, a vast number of red-hot stones, at least three hundred feet higher than my head, as I stood upon the brink; but as there was no wind, they fell perpendicularly back from whence they had been discharged. The other was filled with red-hot liquid matter, like that in the furnace of a glass-house; raging and working like the waves of the sea, with a short abrupt noise. This matter would sometimes boil over, and run down the side of the hill, appearing at first red-hot, but changing colour as it hardened and cooled. Had the wind driven in our faces, we had been in no small danger of stifling by the sulphureous smoke, or being killed by the masses of melted minerals, that were shot from the bottom. But as the wind was favourable, I had an opportunity of surveying this amazing scene for above an hour and a half together. On the fifth of June, after an *horrid noise*, the mountain was seen at Naples to work over; and about three days after, its thunders were renewed so, that not only the windows in the city, but all the houses shook. From that time it continued to overflow, and sometimes at night were seen columns of fire shooting upward from its summit. On the tenth, when all was thought to be over, the mountain again renewed its terrors, roaring and raging most violently. One cannot form a juster idea of the *noise*, in the most violent fits of it, than by imagining a mixed sound, made up of *the raging of a tempest, the murmur of a troubled sea, and the roaring of thunder and artillery*, confused all together. Though we heard this at the distance of twelve miles, yet it was very terrible. I therefore resolved to approach nearer to the mountain; and accordingly, three or four of us got into a boat, and were set ashore at a little town, situated at the foot of the mountain. From thence we rode about four or five miles, before we came to the torrent of fire that was descending from the side

of the volcano; and here the *roaring* grew exceeding loud and terrible as we approached. I observed a mixture of colours in the cloud, above the crater, green, yellow, red, blue. There was likewise a ruddy dismal light in the air, over that tract where the burning river flowed. These circumstances, set off and augmented by the horror of the night, made a scene the most uncommon and astonishing I ever saw; which still increased as we approached the burning river. Imagine a vast torrent of liquid fire, rolling from the top, down the side of the mountain, and with irresistible fury bearing down and consuming vines, olives, and houses; and divided into different channels, according to the inequalities of the mountain. The largest stream seemed half a mile broad at least, and five miles long. I walked so far before my companions up the mountain, along the side of the river of fire, that I was obliged to retire in great haste, the sulphureous steam having surprised me, and almost taken away my breath. During our return, which was about three o'clock in the morning, the roaring of the mountain was heard all the way, while we observed it throwing up huge spouts of fire and burning stones, which falling, resembled the stars in a rocket. Sometimes I observed two or three distinct columns of flame, and sometimes one only that was large enough to fill the whole crater. These burning columns, and fiery stones, seemed to be shot a thousand feet perpendicular above the summit of the volcano! and in this manner the mountain continued raging for six or eight days after. On the eighteenth of the same month the whole appearance ended, and the mountain remained perfectly quiet, without any visible smoke or flame."

But the latest and clearest account of this most formidable phænomenon we have from the late Envoy Sir William Hamilton. He begins with remarking, "That the frequent slight eruptions of lava for some years past had issued from near the summit, and ran in small channels in different directions down the flanks of the mountain, and from running in covered channels, had often an appearance as if they came immediately out of the sides of Vesuvius, but such lavas had not sufficient force to reach the cultivated parts at the foot of the mountain. In the year 1779, the whole quantity of the lava in fusion having been at once thrown up with violence out of the crater of Vesuvius, and a great part of it falling, and cooling on its cone, added much to the solidity of the walls of this huge natural chimney, and had not of late years allowed of a sufficient discharge of lava to calm that fermentation, which by the subterraneous noises heard at times, and by the explosions of scoriæ and ashes, was known to exist within the bowels of the volcano; so that the eruptions of late years, before this last, were simply from the lava having boiled over the crater, the sides being sufficiently strong to confine it, and oblige it to rise and overflow. The mountain had been remarkably quiet for seven months before the late eruption, nor did the usual smoke issue from its crater, but at times it emitted small clouds of smoke that floated in the air in the shape of little trees.

SIGNS.

It was remarked by the Father Antonio di Petrizzi, a capuchin friar (who printed an account of the late eruption) from his convent close to the unfortunate town of Torre del Greco, that for some days preceding this eruption a thick vapour was seen to surround the mountain, about a quarter of a mile beneath its crater, as it was remarked by him, and others at the same time, that both the sun and the moon had often an unusual reddish cast.

The water of the great fountain at Torre del Greco began to decrease some days before the eruption, so that the wheels of a corn-mill, worked by that water, moved very slowly; it was necessary in all the other wells of the town and its neighbourhood to lengthen the ropes daily, in order to reach at the water; and some of the wells became quite dry. Although most of the inhabitants were sensible of this phenomenon, not one of them seems to have suspected the true cause of it. Eight days also before the eruption, a man and two boys, being in a vineyard above Torre del Greco (and precisely on the spot where one of the new mouths opened, whence the principal current of lava that destroyed the town issued) were much alarmed by a sudden puff of smoke which issued from the earth close to them, and was attended with a slight explosion.

Had this circumstance, with that of the subterraneous noises heard at Resina for two days before the eruption (with the additional one of the decrease of water in the wells) been communicated at the time, it would have required no great foresight to have been certain that an eruption of the volcano was near at hand, and that its force was directed particularly towards that part of the mountain.

ERUPTION.

Judging from these appearances, I warned my family not to be suddenly alarmed, as I had reason to expect an earthquake; and curiosity led me to visit the mountain. It was about noon on the 20th of October, 1769, when on a sudden I heard an uncommon *bellowing* within its cavity, and about a quarter of a mile from the place where I stood, the mountain was split in twain, and with much noise from this chasm a fountain of liquid fire shot up many feet high, and like a torrent rolled on directly towards where I stood. The earth shook, at the same time that a volley of pumice stones fell thick upon us; in an instant, clouds of black smoke and ashes caused almost a total darkness; the *explosions* from the top of the mountain *were much louder than any thunder I ever heard, and the smell of the sulphur was very offensive.* My guide, alarmed, took to his heels; and I must confess, that I was not at my ease. I followed close, and we ran near three miles without stopping; as the earth continued to shake under our feet, I was apprehensive of the opening of a fresh mouth, which might have cut off our retreat. I also feared that the *violent explosions* would detach some of the rocks off the mountain of Somma, under which we were obliged to pass; besides, the pumice-stones, falling upon us like hail, were of such a size as to cause a disagreeable sensation upon the part where they fell. After having taken breath, as the earth still trembled greatly, I thought it most prudent to leave the mountain, and return to my villa; where I found my family in a great alarm, at the continual and violent explosions of the volcano, which shook our house to its very foundation, the doors and windows swinging upon their hinges.

The noise and smell of sulphur increasing, we removed from our villa to Naples; and I thought proper, as I passed by Portici, to inform the court of what I had seen; and humbly offered it as my opinion, that his Sicilian Majesty should leave the neighbourhood of the threatening mountain. However, the court did not leave Portici till about twelve of the clock. I observed, in my way to Naples, which was in less than two hours after I had left the mountain, that the lava had actually covered three miles of the very road through which we had retreated. It is astonishing that it should have run so fast; as I have since seen, that the river of lava, in the Atrio di Cavello, was sixty and seventy feet deep, and in some places near two miles broad. When his Sicilian Majesty quitted Portici, the *noise* was greatly increased; and the concussion of the air from the *explosions* was so violent, that, in the king's palace, doors and windows were forced open; and even one door there, which was locked, was nevertheless burst open. At Naples, the same night, many windows and doors flew open; in my house, which is not on the side of the town next Vesuvius, I tried the experiment of unbolting my windows, when they flew wide open upon every explosion of the mountain. Besides these explosions, which were very frequent, there was a continued *subterraneous* and *violent rumbling noise,* which lasted this night about five hours. I have imagined, that this extraordinary noise might be owing to the lava in the bowels of the mountain having met with a deposition of rain water; and that the conflict between the fire and the water may, in some measure, account for so extraordinary a crackling and hissing noise. Padre Torre, who has wrote so much and so well upon the subject of Mount Vesuvius, is also of my opinion. And indeed it is natural to imagine, that there may be rain-water lodged in many of the caverns of the mountain; as, in the great eruption of Mount Vesuvius in 1631, it is well attested, that several towns, among which Portici and Torre del Greco, were destroyed, by a torrent of *boiling water* having burst out of the mountain with the lava, by which thousands of lives were lost. About four years ago, Mount Etna in Sicily threw up hot water also, during an eruption.

The confusion at Naples this night cannot be described; his Sicilian Majesty's hasty retreat from Portici added to the alarm; all the churches were opened and filled; the streets were thronged with processions of saints: but I shall avoid entering upon a description of the various ceremonies that were performed in this capital, to quell the fury of the turbulent mountain.

Tuesday the 20th, it was impossible to judge of the situation of Vesuvius, on account of the smoke and ashes, which covered it entirely, and spread over Naples also, the sun appearing as through a thick London fog, or a smoked glass; small ashes fell all this day at Naples. The lavas on both sides of the mountain ran violently; but there was little or no noise till about nine o'clock at night, when the same *uncommon rumbling* began again, accompanied with explosions as before.

Wednesday twenty-first, was more quiet than the preceding days, though the lavas ran briskly.

Portici was once in some danger, had not the lava taken a different course when it was only a mile and a half from it; towards night, the lava slackened.

Thursday twenty-second, about ten of the clock in the morning, the same *thundering noise* began again, but with more violence than the preceding days; the oldest men declared, they had never heard the like; and, indeed, it was very alarming: we were in expectation every moment of some dire calamity. The ashes, or rather small cinders, showered down so fast, that the people in the streets were obliged to use umbrellas, or flap their hats; these ashes being very offensive to the eyes. The tops of the houses, and the balconies, were covered above an inch thick with these cinders. Ships at sea, twenty leagues from Naples, were also covered with them, to the great astonishment of the sailors.

It is worthy of observation, that at this time there were no clouds in the air, yet these ashes were *wet*, and accompanied with a *salt taste*. Hence Dr. Emanuel Scotti, Professor of Philosophy in the University of Naples, supposes, in his printed account of this eruption, that this *water* is the product of an explosion of *inflammable* and *oxygen airs*.

ÆTNA.

This mountain is divided into three distinct regions, called La Regione Culta: the Fertile Region; La Regione Sylvosa, the Woody Region; and La Regione Deserta, the Barren Region.

The three are as different, both in climate and productions, as the three zones of the earth: and perhaps with equal propriety might have been stiled the torrid, the temperate, and the frigid zone. The first region surrounds the foot of the mountain, and constitutes the most fertile country in the world on all sides of it, to the extent of about fourteen or fifteen miles, where the woody region begins. It is composed almost entirely of lava, which, after a number of ages, is at last converted into the most fertile of all soils.

Every eruption generally forms a new mountain. As the great Crater of Ætna itself is raised to such an enormous height above the lower regions of the mountain, it is not possible that the internal fire raging for vent, even round the base, and no doubt vastly below it, should be carried to the height of twelve or thirteen thousand feet to the summit of Ætna. It has therefore generally happened, that after shaking the mountain and its neighbourhood for some time, it at last bursts open its side. At first it only sends forth a thick smoke and showers of ashes, that lay waste the adjacent country: these are soon followed by red-hot stones, and rocks of a great size, thrown to an immense height in the air. The fall of these stones, together with the quantity of ashes discharged at the same time, at last form one of these spherical and conical mountains. Sometimes this process is finished in the course of a few days: sometimes it lasts for months, which was the case in the eruption of 1669. In that case the mountains formed are of a great size; some of them are not less than seven or eight miles round, and upwards of one thousand feet in perpendicular height: others are not more than two or three miles round, and three or four hundred feet high.

After the new mountain is formed, the lava generally bursts out from its lower side; and bearing away every thing before it, is for the most part terminated by the sea. This is the common progress of an eruption; however, it sometimes happens, though rarely, that the lava bursts at once from the side of the mountain, without all these attending circumstances; and this is commonly the case with the eruption of Vesuvius, where the elevation being much smaller, the melted matter is generally carried up into the crater of the mountain, which then discharges showers of stones and ashes from the mouth of the volcano, without forming any new mountain, but only adding considerably to the height of the old one; till at last the lava, rising near the summit, bursts the side of the crater, and the eruption is declared. This has been the case with two eruptions lately; but Ætna is upon a much larger scale, and one crater is not enough to give vent to such oceans of liquid fire.

A Sicilian gentleman saw in an eruption of that mountain, large rocks of fire discharged to the height of some thousand feet, with a noise more terrible than that of thunder. He measured from the time of their greatest elevation, till they reached the ground, and found they took twenty-one seconds to descend, which (the spaces being as the squares of the times) amounted to upwards of seven thousand feet!

After contemplating these objects for some time, says another traveller, we set off, and soon after arrived at the foot of the great crater of Ætna. This is of an exact conical figure, and rises equally

on all sides. It is composed solely of ashes, and other burnt materials, discharged from the mouth of the volcano, which is in its centre. This conical mountain is of a very large size: its circumference cannot be less than ten miles. Here we took a second rest, as the greatest part of our fatigue still remained. The mercury had fallen to 20 4½. We found this mountain excessively steep; and although it had appeared black, yet it was likewise covered with snow, but the surface (luckily for us) was spread over with a pretty thick layer of ashes, thrown from the crater. Had it not been for this, we should have been able to get to the top.

The circumference of this zone or great circle on Ætna is not less than seventy or eighty miles. It is every where covered by the vineyards, orchards, and corn-fields that compose the Regione Culta, or the Fertile Region. The last zone is much broader than the others, and extends on all sides to the foot of the mountain. Its whole circumference is 183 miles.

The present crater of this immense volcano is a circle of about three miles and a half in circumference. It goes shelving down on each side, and forms a regular hollow, like a vast amphitheatre. From many places of this space issue volumes of sulphureous smoke, which being much heavier than the circumambient air, instead of rising in it, as smoke generally does, immediately on its getting out of the crater, rolls down the side of the mountain like a torrent, till coming to that part of the atmosphere of the same specific gravity with itself, it shoots off horizontally; and forms a large tract in the air, according to the direction of the wind; which happily for us, carried it exactly to the side opposite to that where we were placed. The crater is so hot that it is very dangerous, if not impossible, to go down into it: besides the smoke is very incommodious, and in many places the surface is so soft, there have been instances of people sinking down into it and paying for their temerity with their lives. Near the centre of the crater is the great mouth of the volcano, that tremendous gulph so celebrated in all ages. We beheld it with awe, and with horror, and were not surprised that it had been considered by the vulgar, as Hecla is at present, as the place of the damned, and its noises as their groans. When we reflect on the immensity of its depth, the vast cells and caverns whence so many lavas have issued; the boiling of the matter, the shaking of the mountain, the explosion of flaming rocks, we must allow that the liveliest imagination hardly ever formed an idea of hell more dreadful.

It is a curious consideration that this mountain should re-unite every beauty and every horror; and in short, all the most opposite and dissimilar objects in nature. Here you observe a gulph, that formerly threw out torrents of fire now covered with the most luxuriant vegetation; and from an object of horror becomes one of delight. Here you gather the most delicious fruits, rising from what was lately a black and barren rock. Here the ground is covered with every flower; and we wander over those beauties, and contemplate this wilderness of sweets without considering that hell and all its terrors, is immediately under our feet, and that a few yards separate us from lakes of liquid fire and brimstone.

But our astonishment still increases, on casting our eyes on the higher regions of the mountain. There we behold in perpetual union, the two elements that are at perpetual war; an immense gulph of fire, for ever existing in the midst of snows, which it has not power to melt; and immense fields of snow and ice for ever surrounding this gulph of fire, which they have not power to extinguish.

An eruption of Mount Ætna, in 1669, was preceded for eighteen days, with a dark, thick sky, thunder, lightning, and frequent tremblings of the earth. The place of eruption was twenty miles from the old mouth: the matter of it was a stream of melted minerals, boiling up and gushing out, as water does at the head of a great river. Having run thus for more than a stone's cast, the extremities began to crust, and turn into porous stones, resembling huge cakes of sea coal, full of a fierce fire. These came rolling over one another, and where any thing opposed, filled up the space and rolled over. But they bore down any common building, and burnt up all that was combustible. This inundation went on about a furlong a day, for nineteen or twenty days. It overwhelmed fourteen towns and villages. The noise of the eruption was heard sixty miles.

On Sunday, March 9, 1755, about noon, Mount Ætna began to cast from its mouth a great quantity of flame and smoke, with a most horrible noise. At four o'clock the air became quite dark and covered with black clouds. At six a shower of stones, each weighing about three ounces, began to fall over all the city of Mascali and its territories. This shower lasted till a quarter past seven; and was succeeded all night by a shower of black sand. On Monday morning at eight, there sprang from the bottom of the mountain a river of scalding-hot water, which in half a quarter of an hour, overflowed all the rugged land that is near the foot of the hill, and suddenly going off, left the whole a

large plain of sand. The stones and sand which remain wherever this water reached, differ in nothing from the stones and sand of the sea, and have even the same saltness. After the water was gone there sprang from the same opening a small stream of fire, which continued for four and twenty hours. On Tuesday, about a mile below this opening, there arose another stream of fire, which being in breadth about four hundred feet, overflowed all the adjacent country.

On the 3d of December, 1754, a stream of liquid fire began to run down the side of Mount Vesuvius, from an opening on the east-side. But it soon ceased running from this orifice, and burst out from a much larger one, about two hundred yards below it. Afterward it burst out from a third orifice, and having ran some space with great fury, the surface then began to cool and incrust, as it ran over gently-declining ground, till it came within about ten yards of the top of a steep declivity. Here the fire collected, as in a reservoir, to supply a cascade, which rushed down from thence in a channel of more than twenty feet wide, and about two hundred yards in length, with a fall of at least fifty feet. After this the stream was less rapid, but grew wider, and spread several miles from its source. It now presented a very different scene from what it afforded before. The cascade (says an eye-witness) looks like melted gold, and tears off large bodies of old lava (so they term the incrustation) which float down the stream, till the intenseness of the heat lifts them from the bottom. But in the lower country, it divides into smaller streams, running with less rapidity: and yet with such violence, that it drives the strongest stone fences before it, and lighting the trees, like torches, affords a most extraordinary, though dismal spectacle.

Not to detain the reader too long on these phænomena, I shall only give him the fine description of another eye-witness, Kircher, respecting an eruption of Mount Ætna.

Proceeding onward, says this traveller, I could not fail to cast my eyes on this justly famed mountain, and I saw it cast forth large volumes of smoke, which entirely covered the whole island. This together with the dreadful noise, filled me with apprehension. The sea itself began to wear a very unusual appearance, covered all over with bubbles. My surprise was increased by the calmness of the weather. I therefore warned my companions, that an earthquake was approaching, and making for the shore with all possible speed, we landed at Tropæ. But we had scarcely arrived at the Jesuit's College in that city, when our ears were stunned with a *horrid sound resembling that of an infinite number of chariots driven fiercely forward, the wheels rattling, and the thongs cracking.* Soon after, the whole tract upon which we stood, seemed to vibrate, as if we were in the scale of a balance wavering. This soon grew more violent, and being no longer able to keep my legs, I was thrown prostrate upon the ground. In the mean time, the universal ruin round me, redoubled my amazement. The crash of falling houses, the tottering of towers, and the groans of the dying, all contributed to raise my terror. On every side of me, I saw nothing but a scene of ruin, danger threatening wherever I could fly. I recommended myself to God as my last refuge. At that hour, O how vain was every sublunary happiness! Wealth, honour, empire, wisdom, all mere useless sounds, and as empty as the bubbles on the deep. Just standing on the threshold of eternity, nothing but GOD was my pleasure, and the nearer I approached, I only loved him the more. After some time, however, I resolved to venture for safety, and running as fast as I could, reached the shore. I did not search long, till I found the boat in which I had landed and my companions also. Our meeting was all silence, with gloomy dread of impending terrors. The place on which we stood, now began to shake most dreadfully, so that being unable to stand, my companions and I caught hold of the shrubs near us, and supported ourselves in that manner. After some time this shock ceasing, we stood up in order to go to Euphæmia, that lay within sight. But when I turned my eyes towards the city, I could see only a dark cloud resting upon the place. This the more surprised us, as the weather was so serene. We waited till the cloud was partly away, then looking for the city, it was totally sunk. Nothing but a putrid lake was seen where it stood. We looked about for some one that could tell us the sad catastrophe, but could see none. All was become a melancholy solitude, a scene of hideous desolation. Such was the fate of the city of Euphæmia. And as we continued our melancholy course along the shore, the whole coast for the space of two hundred miles presented nothing but the remains of cities.

EARTHQUAKE AT LISBON.

Earthquakes have so great affinity with the eruptions of volcanos, that, according to our plan, we will proceed to the consideration of one of the most memorable, and in the recollection of most of us.

We should notice that, previous to an eruption of Vesuvius, the earth always trembles, and subterraneous explosions are heard. On the first of November, 1755, the æra so fatal to Lisbon, the island of Madeira was violently shaken by an earthquake, accompanied with subterraneous explosions. So thoroughly convinced, indeed, are the inhabitants of volcanic countries of the connection between earthquakes and volcanoes, that when a great eruption takes place from a volcano, they congratulate themselves on having escaped an earthquake.

Earthquakes, as well as volcanic eruptions, are always preceded by a violent agitation of the sea. Previous to the breaking out of Vesuvius, the sea retires from the adjacent shores till the mountain is burst open, and then it returns with such impetuosity, as to overflow its usual boundary. About an hour after the first shocks, which alarmed the city of Lisbon in 1755, the sea was observed to come rushing towards the city like a torrent, though against both wind and tide; it rose forty feet higher than was ever known, and as suddenly subsided. A ship, fifty leagues off at sea, received so violent a shock as greatly to injure the deck, &c. The same effect was observed at Cádiz, and at a variety of ports throughout the Mediterranean, and, indeed, more or less, all over Europe.

In 1691 and 1698 vast torrents of boiling water flowed from the crater of Vesuvius, previous to the eruption of fire: and what was, perhaps, still more remarkable, many species of sea-shells, in a calcined state, were found on the brink of the crater, and also in the channel formed by the flood. The same thing happened at Ætna, in 1755, when a dreadful torrent of boiling water flowed from the crater at the time of an eruption of fire. Sir William Hamilton observes, that the sea-shells emitted along with the water clearly indicate a communication with the sea. All warm springs probably receive their heat from the action of pyrites, near which the water passes.

The following exact account of the great Lisbon earthquake is extracted from a volume of letters, published by the Rev. Mr. Davy.

There was never a finer morning seen than the first of November (1755); the sun shone out in its full lustre; the whole face of the sky was perfectly serene and clear, and not the least signal or warning of that approaching event, which has made this once flourishing, opulent, and populous city, a scene of the utmost horror and desolation, except only such as served to alarm, but scarcely left a moment's time to fly from the general destruction.

It was on the morning of this fatal day, between the hours of nine and ten, that I was sat down in my apartment, just finishing a letter, when the papers and table I was writing on began to tremble with a gentle motion, which rather surprised me, as I could not perceive a breath of wind stirring; whilst I was reflecting with myself what this could be owing to, but without having the least apprehension of the real cause, the whole house began to shake from the very foundation, which at first I imputed to the rattling of several coaches in the main street, which usually passed that way, at this time, from Belem to the palace: but on hearkening more attentively, I was soon undeceived, as I found it was owing to a strange frightful kind of noise underground, resembling the hollow distant rumbling of thunder; all this passed in less than a minute, and I must confess I now began to be alarmed, as it naturally occurred to me, that this noise might possibly be the forerunner of an earthquake, as I remembered that which had happened about six or seven years ago, in the island of Madeira, commenced in the same manner, though it did little or no damage.

Upon this I threw down my pen, and started upon my feet, remaining a moment in suspense, whether I should stay in the apartment, or run into the street, as the danger in both places seemed equal; and still flattering myself that this tremor might produce no other effects than such inconsiderable ones as had been felt at Madeira; but in a moment I was roused from my dream, being instantly stunned with a most horrid crash, as if every edifice in the city had tumbled down at once. The house I was in shook with such violence, that the upper stories immediately fell, and though my apartment (which was the first floor) did not then share the same fate, yet every thing was thrown out of its place in such a manner, that it was with no small difficulty I kept my feet, and expected nothing less than to be soon crushed to death, as the walls continued rocking to and fro in the frightfullest manner, opening in several places, large stones falling down on every side from the cracks, and the ends of most of the rafters starting out from the roof. To add to this terrifying scene, the sky in a moment became so gloomy, that I could now distinguish no particular object; it was an Egyptian darkness indeed, such as might be felt; owing, no doubt, to the prodigious clouds of dust and lime, raised from so violent a concussion, and as some reported, to sulphureous exhalations, but this I cannot affirm; however, it is certain I found myself almost choked for near ten minutes.

As soon as the gloom began to disperse, and the violence of the shock seemed pretty much abated, the first object I perceived in the room was a woman sitting on the floor, with an infant in her arms, all covered with dust, pale and trembling; I asked her how she got hither: but her consternation was so great, that she could give me no account of her escape; I suppose, that when the tremor first began, she ran out of her own house, and finding herself in such imminent danger from the falling of stones, retired into the door of mine, which was almost contiguous to her's, for shelter, and when the shock increased, which filled the door with dust and rubbish, ran up stairs in to my apartment, which was then open: be it as it might, this was no time for curiosity. I remember the poor creature asked me, in the utmost agony, if I did not think that the world was at an end; at the same time she complained of being choked, and begged for God's sake I would procure her a little drink; upon this I went to a closet where I kept a large jar with water (which you know is sometimes a pretty scarce commodity in Lisbon), but finding it broken in pieces, I told her she must not now think of quenching her thirst, but saving her life, as the house was just falling on our heads, and if a second shock came, would certainly bury us both; I bade her take hold of my arm, and that I would endeavour to bring her into some place of security.

I shall always look upon it as a particular providence, that I happened on this occasion to be undressed; for had I dressed myself, as I proposed, when I got out of bed, in order to breakfast with a friend, I should, in all probability, have run into the street at the beginning of the shock, as the rest of the people in the house did, and consequently have had my brains dashed out, as every one of them had; however, the imminent danger I was in did not hinder me from considering that my present dress, only a gown and slippers, would render my getting over the ruins almost impracticable: I had, therefore, still presence of mind enough left to put on a pair of shoes and a coat, the first that came in my way, which was every thing I saved, and in this dress I hurried down stairs, the woman with me, holding by my arm, and made directly to that end of the street which opens to the Tagus, but finding the passage this way entirely blocked up with the fallen houses to the height of their second stories, I turned back to the other end which led into the main street (the common thoroughfare to the palace), and having helped the woman over a vast heap of ruins, with no small hazard to my own life, just as we were going into the street, as there was one part I could not well climb over without the assistance of my hands, as well as my feet, I desired her to let go her hold, which she did, remaining two or three feet behind me, at which time there fell a vast stone from a tottering wall, and crushed both her and the child in pieces: so dismal a spectacle at any other time would have affected me in the highest degree, but the dread I was in of sharing the same fate myself, and the many instances of the same kind which presented themselves all around, were too shocking to make me dwell a moment on this single subject.

I had now a long narrow street to pass, with the houses on each side four or five stories high, all very old, the greater part already thrown down, or continually falling, and threatening the passengers with inevitable death at every step, numbers of whom lay killed before me, or, what I thought far more deplorable, so bruised and wounded, that they could not stir to help themselves. For my own part, as destruction appeared to me unavoidable, I only wished I might be made an end of at once, and not have my limbs broken, in which case I could expect nothing else but to be left upon the spot, lingering in misery, like these poor unhappy wretches, without receiving the least succour from any person.

As self-preservation, however, is the first law of nature, these sad thoughts did not so far prevail as to make me totally despair. I proceeded on as fast as I conveniently could, though with the utmost caution; and having at length got clear of this horrid passage, I found myself safe and unhurt in the large open space before St. Paul's church, which had been thrown down a few minutes before, and buried a great part of the congregation, that was generally pretty numerous, this being reckoned one of the most populous parishes in Lisbon. Here I stood some time, considering what I should do, and not thinking myself safe in this situation, I came to the resolution of climbing over the ruins of the west end of the church, in order to get to the river side, that I might be removed, as far as possible, from the tottering houses, in case of a second shock.

This, with some difficulty, I accomplished, and here I found a prodigious concourse of people, of both sexes, and of all ranks and conditions, among whom I observed some of the principal canons of the patriarchal church, in their purple robes and rochets, as these all go in the habit of bishops; several priests who had run from the altars in their sacerdotal vestments in the midst of their celebrating

mass; ladies half dressed, and some without shoes; all these, whom their mutual dangers had here assembled to a place of safety, were on their knees at prayers, with the terrors of death in their countenances, every one striking his breast, and crying out incessantly, *Miserecordia meu Dios.*

In the midst of our devotions, the second great shock came on, little less violent than the first, and completed the ruin of those buildings which had been already much shattered. The consternation now became so universal, that the shrieks and cries of *Miserecordia* could be distinctly heard from the top of St. Catherine's hill, at a considerable distance off, whither a vast number of people had likewise retreated; at the same time we could hear the fall of the parish church there, whereby many persons were killed on the spot, and others mortally wounded. You may judge of the force of this shock, when I inform you, it was so violent, that I could scarce keep on my knees, but it was attended with some circumstances still more dreadful than the former.—On a sudden I heard a general outcry, 'The sea is coming in, we shall be all lost.'—Upon this, turning my eyes towards the river, which in that place is near four miles broad, I could perceive it heaving and swelling in a most unaccountable manner, as no wind was stirring; in an instant there appeared, at some small distance, a large body of water, rising like a mountain; it came on foaming and roaring, and rushed towards the shore with such impetuosity, that we all immediately ran for our lives, as fast as possible; many were actually swept away, and the rest above their waist in water at a good distance from the banks. For my own part, I had the narrowest escape, and should certainly have been lost, had I not grasped a large beam that lay on the ground, till the water returned to its channel, which it did almost at the same instant, with equal rapidity. As there now appeared at least as much danger from the sea as the land, and I scarce knew whither to retire from shelter, I took a sudden resolution of returning back with my clothes all dropping, to the area of St. Paul's: here I stood some time, and observed the ships tumbling and tossing about, as in a violent storm; some had broken their cables, and were carried to the other side of the Tagus; others were whirled round with incredible swiftness; several large boats were turned keel upwards; and all this without any wind, which seemed the more astonishing. It was at the time of which I am now speaking, that the fine new quay, built entirely of rough marble, at an immense expence, was entirely swallowed up, with all the people on it, who had fled thither for safety, and had reason to think themselves out of danger in such a place; at the same time a great number of boats and small vessels, anchored near it (all likewise full of people, who had retired thither for the same purpose) were all swallowed up, as in a whirlpool, and never more appeared.

This last dreadful incident I did not see with my own eyes, as it passed three or four stones throws from the spot where I then was, but I had the account as here given from several masters of ships, who were anchored within two or three hundred yards of the quay, and saw the whole catastrophe. One of them in particular informed me, that when the second shock came on, he could perceive the *whole* city waving backwards and forwards, like the sea when the wind first begins to rise; that the agitation of the earth was so great even under the river, that it threw up his large anchor from the mooring, which swam, as he termed it, on the surface of the water; that immediately upon this extraordinary concussion, the river rose at once near twenty feet, and in a moment subsided; at which instant he saw the quay, with the whole concourse of people upon it, sink down, and at the same time every one of the boats and vessels that were near it were drawn into the cavity, which he supposes instantly closed upon them, inasmuch as not the least sign of a wreck was ever seen afterwards. This account you may give full credit to, for as to the loss of the vessels, it is confirmed by every body; and with regard to the quay, I went myself a few days after, to convince myself of the truth, and could not find even the ruins of a place, where I had taken so many agreeable walks, as this was the common rendezvous of the factory in the cool of the evening. I found it all deep water, and in some parts scarcely to be fathomed.

This is the only place I could learn which was swallowed up in or about Lisbon, though I saw many large cracks and fissures in different parts, and an odd phenomenon I must not omit, which was communicated to me by a friend who has a house and wine-cellars on the other side of the river, viz. that the dwelling-house being first terribly shaken, which made all the family run out, there presently fell down a vast high rock near it, that upon this the river rose and subsided in the manner already mentioned, and immediately a great number of small fissures appeared in several contiguous pieces of ground, whence there spouted like a *jet d' eau* a large quantity of fine white sand, to a prodigious height.

I had not been long in the area of St. Paul's, when I felt the third shock, which though somewhat

less violent than the two former, the sea rushed in again, and retired with the same rapidity, and I remained up to my knees in water, though I had gotten upon a small eminence at some distance from the river, with the ruins of several intervening houses to break its force. At this time I took notice the waters retired so impetuously, that some vessels were left quite dry, which rode in seven fathom water: the river thus continued alternately rushing on and retiring several times together, in such sort, that it was justly dreaded Lisbon would now meet the same fate which a few years ago had befallen the city of Lima.

Perhaps you may think the present doleful subject here concluded; but, alas! the horrors of the first of November are sufficient to fill a volume. As soon as it grew dark, another scene presented itself little less shocking than those already described—the whole city appeared in a blaze, which was so bright that I could easily see to read by it. It may be said, without exaggeration, it was on fire at least in an hundred different places at once, and thus continued burning for six days together, without intermission, or the least attempt being made to stop its progress.

I could never learn, that this terrible fire was owing to any subterraneous eruption, as some reported, but to three causes, which all concurring at the same time, will naturally account for the prodigious havoc it made; the first of November being All Saints Day, a high festival among the Portuguese, every altar in every church and chapel (some of which have more than twenty) was illuminated with a number of wax tapers and lamps, as customary; these setting fire to the curtains and timber work that fell with the shock, the conflagration soon spread to the neighbouring houses, and being there joined with the fires in the kitchen chimnies, increased to such a degree, that it might easily have destroyed the whole city, though no other cause had occurred, especially as it met with no interruption.

The fire, by some means or other, may be said to have destroyed the whole city, at least every thing that was grand and valuable in it; and the damage on this occasion is not to be estimated.

During this calamitous scene, it is impossible to conceive the horrors and wretchedness of the unhappy inhabitants. The jaws of death were opened to swallow them up; ruin had seized all their possessions, and those dear connexions to which they might have looked for consolation in their sorrows, were for ever buried in the merciless abyss. All was ruin and desolation. Every countenance indicated the extremity of affliction and despair; and the whole country formed a wide scene of undescribable horror.

The whole number of persons that perished, including those who were burnt, or afterwards crushed to death whilst digging in the ruins, is supposed, on the lowest calculation, to amount to more than sixty thousand; and though the damage in other respects cannot be computed, yet you may form some idea of it, when I assure you, that this extensive and opulent city is now nothing but a vast heap of ruins, that the rich and poor are at present upon a level, some thousands of families which but the day before had been easy in their circumstances, being now scattered about in the fields, wanting every conveniency of life, and finding none able to relieve them.

As this is one of the most exact accounts of an earthquake, so we are favoured by Sir William Hamilton with a full description of the eruption of Vesuvius, which happened in 1794.

Sir William Hamilton begins his narrative with remarking, that the frequent slight eruptions of lava for some years past had issued from near the summit, and ran in small channels in different directions down the flanks of the mountain, and from running in covered channels, had often an appearance as if they came immediately out of the sides of Vesuvius, but such lavas had not sufficient force to reach the cultivated parts at the foot of the mountain. In the year 1779, the whole quantity of lava in fusion having been at once thrown up with violence out of the crater of Vesuvius, and a great part of it falling, and cooling on its cone, added much to the solidity of the walls of this huge natural chimney, and had not of late years allowed of a sufficient discharge of lava to calm that fermentation, which by the subterraneous noises heard at times, and by the explosions of scoriæ and ashes, was known to exist within the bowels of the volcano; so that the eruptions of late years, before this last, were simply from the lava having boiled over the crater, the sides being sufficiently strong to confine it, and oblige it to rise and overflow. The mountain had been remarkably quiet for seven months before the late eruption, nor did the usual smoke issue from its crater, but at times it emitted small clouds of smoke that floated in the air in the shape of little trees. It was remarked by the Father Antonio di Petrizzi, a capuchin friar (who printed an account of the late eruption) from his convent close to the unfortunate town of Torre del Greco, that for some days preceding this eruption a thick

vapour was seen to surround the mountain, about a quarter of a mile beneath its crater, as it was remarked by him, and others at the same time, that both the sun and the moon had often an unusual reddish cast.

The water of the great fountain of Torre del Greco began to decrease some days before the eruption, so that the wheels of a corn-mill, worked by the water, moved very slowly; it was necessary in all the other wells of the town and its neighbourhood to lengthen the ropes daily, in order to reach at the water; and some of the wells became quite dry. Although most of the inhabitants were sensible of this phenomenon, not one of them seems to have suspected the true cause of it. Eight days also before the eruption, a man and two boys, being in a vineyard above Torre del Greco (and precisely on the spot where one of the new mouths opened, whence the principal current of lava that destroyed the town issued) were much alarmed by a sudden puff of smoke which issued from the earth close to them, and was attended with a slight explosion.

Had this circumstance, with that of the subterraneous noises heard at Resina for two days before the eruption (with the additional one of the decrease of water in the wells) been communicated at the time, it would have required no great foresight to have been certain that an eruption of the volcano was near at hand, and that its force was directed particularly towards that part of the mountain.

On the 12th of June 1794, in the morning, there was a violent fall of rain, and soon after the inhabitants of Resina, situate directly over the ancient town of Herculaneum, were sensible of a rumbling subterraneous noise, which was not heard at Naples.

From the month of January to the month of May, the atmosphere was generally calm, and there was continual dry weather. In the month of May there was a little rain, but the weather was unusually sultry. For some days preceding the eruption, the Duke della Torre, a learned and ingenious nobleman, who published two letters upon the subject of the eruption, observed by his electrometers, that the atmosphere was charged in excess with the electric fluid, and continued so for several days during the eruption.

About eleven o'clock on the night of the 12th of June, the inhabitants of Naples were all sensible of a violent shock of an earthquake; the undulatory motion was evidently from east to west, and appeared to have lasted near half a minute. The sky, which had been quite clear, was soon after covered with black clouds. The inhabitants of the towns and villages, which are very numerous at the foot of Vesuvius, felt this earthquake still more sensibly, and say, that the shock at first was from the bottom upwards, after which followed the undulation from east to west. This earthquake extended all over the Campagna Felice; and the royal palace at Caserta, which is fifteen miles from Naples, and one of the most magnificent and solid buildings in Europe (the walls being eighteen feet thick) was shook in such a manner as to cause great alarm, and all the chamber bells rang. It was likewise much felt at Beneventum, about thirty miles from Naples; and at Ariano in Puglia, which is at a much greater distance; both these towns, indeed, have been often afflicted with earthquakes.

On Sunday the 15th of June, soon after ten o'clock at night, another shock of an earthquake was felt at Naples, but did not appear to be quite so violent as that of the 12th, nor did it last so long; at the same moment a fountain of bright fire, attended with a very black smoke and a loud report, was seen to issue, and rise to a great height, from about the middle of the cone of Vesuvius; soon after another of the same kind broke out at some little distance lower down; then, as is supposed by the blowing up of a covered channel full of red hot lava, it had the appearance as if the lava had taken its course directly up the steep cone of the volcano. Fresh fountains succeeded one another hastily, and all in a direct line tending, for about a mile and a half down, towards the towns of Resina and Torre del Greco. Sir William Hamilton could count fifteen of them, and believes there were others obscured by the smoke. It seems probable, that all these fountains of fire, from their being in such an exact line, proceeded from one and the same long fissure down the flanks of the mountain, and that the lava and other volcanic matter forced its way out of the widest parts of the crack, and formed there the little mountains and craters that will be described in their proper place. It is impossible that any description can give an idea of this fiery scene, or of the horrid noises that attended this great operation of nature. It was a mixture of the loudest thunder, with incessant reports, like those from a numerous heavy artillery, accompanied by a continual hollow murmur, like that of the roaring of the ocean during a violent storm; and, added to these was another blowing noise, like that of the ascending of a large flight of sky-rockets, or that which is produced by the action of the enormous bellows on the surface of the Carron iron foundery in Scotland. The frequent falling of the huge stones and scoriæ,

which were thrown up to an incredible height from some of the new mouths, and one of which having been since measured by the Abbé Tata was ten feet high, and thirty-five in circumference, contributed undoubtedly to the concussion of the earth and air, which kept all the houses at Naples for several hours in a constant tremor, every door and window shaking and rattling incessantly, and the bells ringing. This was an awful moment! The sky, from a bright full moon and star-light, began to be obscured; the moon had presently the appearance of being in an eclipse, and soon after was totally lost in obscurity. The murmur of the prayers and lamentations of a numerous populace forming various processions, and parading in the streets, added to the horror. As the lava did not appear to have yet a sufficient vent, and it was now evident that the earthquakes already felt had been occasioned by the air and fiery matter confined within the bowels of the mountain, and probably at no small depth (considering the extent of those earthquakes) Sir William recommended to the company that was with him, who began to be much alarmed, rather to go and view the mountain at some greater distance, and in the open air, than to remain in the house, which was on the sea-side, and in the part of Naples that is nearest and most exposed to Vesuvius. They accordingly proceeded to Posilipo, and viewed the conflagration, now become still more considerable, from the sea-side under the mountain; but whether from the eruption having increased, or from the loud reports of the volcanic explosions being repeated by the mountain behind them, the noise was much louder, and more alarming than that they had heard in their first position. After some time, and which was about two o'clock in the morning of the 16th, having observed that the lavas ran in abundance, freely, and with great velocity, having made a considerable progress towards Resina, the town which it first threatened, and that the fiery vapours which had been confined had now free vent through many parts of a crack of more than a mile and a half in length, as was evident from the quantity of inflamed matter and black smoke, which continued to issue from the new mouths above-mentioned, without any interruption, our author concluded that at Naples all danger from earthquakes, which had been his greatest apprehension, was totally removed, and he returned to his former station at St. Lucia at Naples.

All this time there was not the smallest appearance of fire or smoke from the crater on the summit of Vesuvius; but the black smoke and ashes issuing continually from so many new mouths, or craters, formed an enormous and dense body of clouds over the whole mountain, and which began to give signs of being replete with the electric fluid, by exhibiting flashes of that sort of zig-zag lightning, which in the volcanic language of the country is called *ferilli*, and which is the constant attendant on the most violent eruptions.

Sir William Hamilton proceeds to remark, that during thirty years that he had resided at Naples, and in which space of time he had been witness to many eruptions of Vesuvius, of one sort or other, he never saw the cloud of smoke so replete with the electric fire, except in the two great eruptions of 1767, that of 1779, and during this more formidable one. The electric fire, in the year 1779, that played constantly with the enormous black cloud over the crater of Vesuvius, and seldom quitted it, was exactly similar to that which is produced, on a small scale, by the conductor of an electrical machine communicating with an insulated plate of glass, thinly spread over with metallic filings, &c. when the electric matter continues to play over it in zig-zag lines without quitting it. He was not sensible of any noise attending that operation in 1779; whereas the discharge of the electrical matter from the volcanic clouds during this eruption, and particularly the second and third days, caused explosions like those of the loudest thunder; and indeed the storms raised evidently by the sole power of the volcano, resembled in every respect all other thunder-storms; the lightning falling and destroying every thing in its course. The house of the Marquis of Berio at St. Jorio, situate at the foot of Vesuvius, during one of these volcanic storms was struck with lightning, which having shattered many doors and windows, and damaged the furniture, left for some time a strong smell of sulphur in the rooms it passed through. Out of these gigantic and volcanic clouds, besides the lightning, both during this eruption and that of 1779, the author adds, he had, with many others, seen balls of fire issue, and some of a considerable magnitude, which bursting in the air, produced nearly the same effect as that from the air-balloons in fire-works, the electric fire that came out having the appearance of the serpents with which those fire-work balloons are often filled. The day on which Naples was in the greatest danger from the volcanic clouds, two small balls of fire, joined together by a small link like a chain-shot, fell close to his Casino at Posilipo; they separated, and one fell in the vineyard above the house, and the other in the sea, so close to it that he heard the splash in the water. The Abbé Tata, in his printed account of this eruption, mentions an enormous ball of this kind which flew out of the

crater of Vesuvius while he was standing on the edge of it, and which burst in the air at some distance from the mountain, soon after which he heard a noise like the fall of a number of stones, or of a heavy shower of hail. During the eruption of the 15th at night, few of the inhabitants of Naples, from the dread of earthquakes, ventured to go to their beds. The common people were either employed in devout processions in the streets, or were sleeping on the quays and open places; the nobility and gentry, having caused their horses to be taken from their carriages, slept in them in the squares and open places, or on the high roads just out of the town. For several days, while the volcanic storms of thunder and lightning lasted, the inhabitants at the foot of the volcano, both on the sea side and the Somma side, were often sensible of a tremor in the earth, as well as of the concussions in the air, but at Naples only the earthquakes of the 12th and 15th of June were distinctly and universally felt: this fair city could not certainly have resisted, had not those earthquakes been fortunately of a short duration. Throughout this eruption, which continued in force about ten days, the fever of the mountain, as has been remarked in former eruptions, showed itself to be in some measure periodical, and generally was most violent at the break of day, at noon, and at midnight.

About four o'clock in the morning of the 16th, the crater of Vesuvius began to show signs of being open, by some black smoke issuing out of it; and at day-break another smoke, tinged with red, issuing from an opening near the crater, but on the other side of the mountain, and facing the town of Ottaiano, shewed that a new mouth had opened there, from which a considerable stream of lava issued, and ran with great velocity through a wood, which it burnt; and having run about three miles in a few hours, it stopped before it had arrived at the vineyards and cultivated lands. The crater, and all the conical part of Vesuvius, was soon involved in clouds and darkness, and so it remained for several days; but above these clouds, although of a great height, fresh columns of smoke were seen from the crater, rising furiously still higher, until the whole mass remained in the usual form of a pine-tree; and in that gigantic mass of heavy clouds the ferilli, or volcanic lightning, was frequently visible, even in the day time. About five o'clock in the morning of the 16th, the lava which had first broken out from the several new mouths on the south side of the mountain, had reached the sea, and was running into it, having overwhelmed, burnt, and destroyed the greatest part of Torre del Greco, the principal stream of lava having taken its course through the very centre of the town. They observed from Naples, that when the lava was in the vineyards in its way to the town, there issued often, and in different parts of it, a bright pale flame, and very different from the deep red of the lava; this was occasioned by the burning of the trees that supported the vines. Soon after the beginning of this eruption, ashes fell thick at the foot of the mountain, all the way from Portici to the Torre del Greco; and what is remarkable, although there were not at that time any clouds in the air, except those of smoke from the mountain, the ashes were wet, and accompanied with large drops of water, which were to the taste very salt; the road, which is paved, was as wet as if there had been a heavy shower of rain. Those ashes were black and coarse, like the sand of the sea-shore; whereas those that fell there, and at Naples some days after, were of a light grey colour, and as fine as Spanish snuff, or powdered bark. They contained many saline particles; those ashes that lay on the ground, exposed to the burning sun, had a coat of the whitest powder on their surface, which to the taste was extremely salt and pungent. In the printed account of the eruption by Emanuel Scotti, doctor of physic and professor of philosophy in the university of Naples, he supposes (which appears to be highly probable) that the water which accompanied the fall of the ashes at the beginning of the eruption, was produced by the mixture of the inflammable and dephlogisticated air.

By the time that the lava had reached the sea, between five and six o'clock in the morning of the 16th, Vesuvius was so completely involved in darkness, that the violent operation of nature that was going on there could no longer be discerned, and so it remained for several days; but the dreadful noise, and the red tinge on the clouds over the top of the mountain, were evident signs of the activity of the fire underneath. The lava ran but slowly at Torre del Greco after it had reached the sea; and on the 17th of June in the morning, its course was stopped, excepting that at times a little rivulet of liquid fire issued from under the smoaking scoriæ into the sea, and caused a hissing noise, and a white vapour smoke; at other times, a quantity of large scoriæ were pushed off the surface of the body of the lava into the sea, discovering that it was red hot under that surface; and even to the latter end of August, the center of the thickest part of the lava that covered the town retained its red heat. The breadth of the lava that ran into the sea, and formed a new promontory there, after having destroyed the greatest part of the town of Torre del Greco, having been exactly measured by the duke della Torre, is of Eng-

lish feet 1204. Its height above the sea is twelve feet, and as many feet under water; so that its whole height is twenty-four feet; it extends into the sea 626 feet. The sea water was boiling as in a cauldron, where it washed the foot of this new formed promontory: and, although our author was at least a hundred yards from it, observing that the sea smoked near his boat, he put his hand into the water, which was literally scalded; and by this time his boatmen observed that the pitch from the bottom of the boat was melting fast, and floating on the surface of the sea, and that the boat began to leak; he therefore retired hastily from this spot, and landed at some distance from the hot lava. The town of Torre del Greco contained about eighteen thousand inhabitants, all of whom (except about fifteen, who, from either age or infirmity, could not be moved, and were overwhelmed by the lava in their houses), escaped either to Castel-a-mare, which was the ancient Stabiæ, or to Naples; but the rapid progress of the lava was such, after it had altered its course from Resina, which town it first threatened, and had joined a fresh lava that issued from one of the new mouths, in a vineyard, about a mile from the town, that it ran like a torrent over the town of Torre del Greco, allowing the unfortunate inhabitants scarcely time to save their lives; their goods and effects were totally abandoned, and indeed several of the inhabitants, whose houses had been surrounded with lava, while they remained in them, escaped from them, and saved their lives the following day, by coming out of the tops of their houses, and walking over the scoriæ on the surface of the red hot lava. Five or six old nuns were taken out of a convent in this manner on the 16th of June, and carried over the hot lava; their stupidity was such as not to have been the least alarmed, or sensible of their danger: one of upwards of ninety years of age was found actually warming herself at a point of red hot lava, which touched the window of her cell, and which she said was very comfortable; and, though now apprized of their danger, they were still very unwilling to leave the convent, in which they had been shut up almost from their infancy, their ideas being as limited as the space they inhabited. Having been desired to pack up whatever they had that was most valuable, they all loaded themselves with biscuits and sweetmeats, and it was but by accident it was discovered that they had left a sum of money behind them, which was recovered for them.

The lava passed over the centre and best part of the town; no part of the cathedral remained above it, except the upper part of a square brick tower, in which were the bells; and it is a curious circumstance, that those bells, although they were neither cracked nor melted, were deprived of their tone as much as if they had been cracked. When the lava first entered the sea, it threw up the water to a prodigious height; and particularly when two points of lava met and inclosed a pool of water, that water was thrown up with great violence, and a loud report: at this time, as well as the day after also, a great many boiled fish were seen floating on the surface of the sea.

The lava over the cathedral, and in other parts of the town, is said to be upwards of forty feet in thickness; the general height of the lava during its whole course was about twelve feet, and in some parts not less than a mile in breadth.

When Sir William Hamilton visited it on the 17th of June, the tops of the houses were just visible here and there in some parts, and the timbers within still burning caused a bright flame to issue out of the surface; in other parts, the sulphur and salts exhaled in a white smoke from the lava, forming a white or yellow crust on the scoriæ round the spots where it issued with the greatest force. He often heard little explosions, and saw that they blew up, like little mines, fragments of the scoriæ and ashes into the air; these he supposes to have been occasioned either by rarefied air in confined cellars, or, perhaps, by small portions of gunpowder taking fire, as few in that country are without a gun and some little portion of gunpowder in their houses. As the church feasts there are usually attended with fireworks and crackers, a firework-maker of the town had a very great quantity of fireworks ready made for an approaching feast, and some gunpowder, all of which had been shut up in his house by the lava, a part of which had even entered one of the rooms; yet he actually saved all his fireworks and gunpowder some days after, by carrying them safely over the scoriæ of the lava, that was red hot underneath. The heat in the streets of the town, at this time, was so great as to raise the thermometer to very near one hundred degrees, and close to the hot lava it rose much higher. Sir William remarked in his way home, that there was a much greater quantity of the petroleum floating on the surface of the sea, and diffusing a very strong and offensive smell, than was usual; for at all times in calms, patches of this bituminous oil are to be seen floating on the surface of the sea between Portici and Naples, and particularly opposite a village called Pietra Bianca. The minute ashes continued falling at Naples; and the mountain, totally obscured by them, continued to alarm the inhabitants with repeated loud explosions.

On Wednesday June 18, the wind having for a short space of time cleared away the thick cloud from the top of Vesuvius, it was now discovered that a great part of its crater, particularly on the west side opposite Naples, had fallen in, which it probably did about four o'clock in the morning of that day, as a violent shock of an earthquake was felt at that moment at Resina, and other parts situate at the foot of the volcano. The clouds of smoke, mixed with the ashes, were of such a density as to appear to have the greatest difficulty in forcing their passage out of the now widely extended mouth of Vesuvius, which certainly, since the top fell in, cannot be much short of two miles in circumference. One cloud heaped on another, and succeeding one another incessantly, formed in a few hours such a gigantic and elevated column of the darkest hue over the mountain, as seemed to threaten Naples with immediate destruction, having at one time been bent over the city, and appearing to be much too massive and ponderous to remain long suspended in the air; it was besides replete with the ferilli, or volcanic lightning, which was stronger than common lightning, just as Pliny the younger describes it in one of his letters to Tacitus, when he says *fulgoribus illæ et similes et majores erant.*

Vesuvius was at this time completely covered, as were all the old black lavas, with a thick coat of those fine light-grey ashes already fallen, which gave it a cold and horrid appearance; and in comparison of the above-mentioned enormous mass of clouds, which certainly, however it may contradict our idea of the extension of our atmosphere, rose many miles above the mountain, it appeared like a molehill, although the perpendicular height of Vesuvius, from the level of the sea, is more than three thousand six hundred feet. The Abbé Braccini, as appears in his printed account of the eruption of Mount Vesuvius in 1631, measured with a quadrant the elevation of a mass of clouds of the same nature, that was formed over Vesuvius during that great eruption, and found it to exceed thirty miles in height. Dr. Scotti, in his printed account of this eruption, says, that the height of this threatening cloud of smoke and ashes, measured from Naples, was found to be of an elevation of thirty degrees.

The storms of thunder and lightning, attended at times with heavy falls of rain and ashes, causing the most destructive torrents of water and glutinous mud, mixed with huge stones, and trees torn up by the roots, continued more or less to afflict the inhabitants on both sides of the volcano until the 7th of July, when the last torrent destroyed many hundred acres of cultivated land, between the towns of Torre del Greco and Torre dell' Annunziata. Some of these torrents, both on the sea side and the Somma side of the mountain, came down with a horrid rushing noise; and some of them, after having forced their way through the narrow gullies of the mountain, rose to the height of more than twenty feet, and were near half a mile in extent. The mud, of which the torrents were composed, being a kind of natural mortar, completely cased up and ruined some thousand acres of rich vineyards; for it soon becomes so hard, that nothing less than a pickaxe can break it up.

The laudable curiosity of our author induced him to go upon Mount Vesuvius, as soon as it was consistent with any degree of prudence, which was not until the 30th of June, and even then it was attended with some risk. The crater of Vesuvius, except at short intervals, had been continually obscured by the volcanic clouds from the 16th, and was so on that day, with frequent flashes of lightning playing in those clouds, and attended as usual with a noise like thunder; and the fine ashes were still falling on Vesuvius, but still more on the mountain of Somma. Sir William went up the usual way by Resina, and observed, in his way through that village, that many of the stones of the pavement had been loosened, and were deranged by the earthquakes, particularly by that of the 18th, which attended the falling in of the crater of the volcano, and which had been so violent as to throw people down, and obliged all the inhabitants of Resina to quit their houses hastily, to which they did not dare return for two days. The leaves of all the vines were burnt by the ashes that had fallen on them, and many of the vines themselves were buried under the ashes, and great branches of the trees that supported them had been torn off by their weight. In short, nothing but ruin and desolation was to be seen. The ashes at the foot of the mountain were about ten or twelve inches thick on the surface of the earth, but in proportion as he ascended, their thickness increased to several feet, not less than nine or ten in some parts; so that the surface of the old rugged lavas, that before was almost impassible, was now become a perfect plain, over which he walked with the greatest ease. The ashes were of a light-grey colour, and exceedingly fine, so that by the footsteps being marked on them as on snow, he learnt that three small parties had been up before him. He saw likewise the track of a fox, which appeared to have been quite bewildered, to judge from the many turns he had made. Even the traces of lizards and other little animals, and of insects, were visible on these fine ashes. Sir William and his companion ascended to the spot whence the lava of the 15th first issued, and followed

" From which circumstances it seems very probable to conclude, that it proceeded from some such subterraneous inkindling as resembles *gunpowder*,* both by the noise it yielded, and in the suddenness of its firing, and its

---

the course of it, which was still very hot (although covered with such a thick coat of ashes) quite down to the sea at Torre del Greco, which is more than five miles. It was not possible to get up to the great crater of Vesuvius, nor had any one yet attempted it. The horrid chasms that existed from the spot where the late eruption first took place, in a straight line for near two miles toward the sea, cannot be imagined. They formed vallies more than two hundred feet deep, and from half a mile to a mile wide; and where the fountains of fiery matter existed during the eruption, were little mountains with deep craters. Ten thousand men, in as many years, could not make such an alteration on the face of Vesuvius. Except the exhalations of sulphureous and vitriolic vapours, which broke out from different spots of the line above-mentioned, and tinged the surface of the ashes and scoriæ in those parts with either a deep or pale-yellow, with a reddish ochre colour, or a bright white, and in some parts with a deep green and azure blue (so that the whole together had the effect of an iris), all had the appearance of a sandy desart. Our adventurers then went on the top of seven of the most considerable of the new-formed mountains, and looked into their craters, which on some of them appeared to be little short of half a mile in circumference; and although the exterior perpendicular height of any of them did not exceed two hundred feet, the depth of their inverted cone within was three times as great. It would not have been possible to have breathed on these new mountains near their craters, if they had not taken the precaution of tying a double handkerchief over their mouths and nostrils; and even with that precaution they could not resist long, the fumes of the vitriolic acid were so exceedingly penetrating, and of such a suffocating quality. They found in one a double crater, like two funnels joined together; and in all there was some little smoke and depositions of salts and sulphurs, of the various colours above-mentioned, just as is commonly seen adhering to the inner walls of the principal crater of Vesuvius.

The reader of sensibility will not object to the length of these notes, exhibiting the most grand and wonderful works of an Almighty power, in a part where the philosophic principles, relatively connected with Botany, are subjects under discussion. We hope and expect, that on this account, the eager inquirer into the science of Botany will excuse what he may judge to be an intrusion on a topic he might feel, at the present time, more anxious to be instructed in.

* Gunpowder, the most terrible engine invented for the destruction of life, whereby mortals imitate the august armoury of the Deity, is generally supposed to be the discovery of Roger Bacon, who died in 1291. Fearful of the mischievous uses, that might arise from this invention, he describes it in mysterious characters, omitting the most essential ingredient. His words are, " Ope salis petræ, sulphuris, et *Lure mope can ubre*, facies, si scias tonitrum, et coruscationem artificium." " By means of salt-petre, sulphur, and Lure mopo can ubre, you can make an artificial thunder and lightning." The barbarous words *Lure mopo can ubre*, are now known to be an anagram for carbonum pulvere, and he mentions " the possibility of its application for overturning cities and empires." Too faithfully has this been verified, but the author of such an application is concealed from us. Polydore Virgil, who appears to have known him, says, " a German, whose birth was ignoble, and whose name I hope never will be handed down to posterity, invented an iron tube, for containing of gunpowder, which was employed by the Venetians in the year 1380." By the Venetians, the use of gunpowder, says Gibbon, was communicated without reproach to the Sultan of Egypt and Persia, their allies against the Ottoman power; the *secret* was soon propagated to the extremities of Asia, and the advantages of the strong and skilful over the weak and unpractised, was annihilation in an instant. Before the end of the century in which it was introduced, it became familiar to all the states in Germany, Italy, Spain, France, and England. If we contrast, continues the historian, the rapid progress of this mischievous invention with the slow and laborious advances of reason, science, and the arts of peace, a philosopher, according to his temper, will either *laugh* or *weep at the folly of mankind*. To contemplate the tremendous power as a chemist, is fortunately our province, for war

powerful expansion when fired; for the noise was as of *many cannon*; this alone proves it to be very sudden.

"The materials of these earthquakes may be different, but their effects will be the same; just as we find the *pulvis fulminans*, as it is called, which hath some of its materials differing from that of common powder; as also *aurum fulminans*, which is yet more differing, both as to its materials and as to its way of kindling, have yet most of the same effects with gunpowder, both as to the flashing and thundering noise, and as to the force or violence. So that as these are differing in many particulars, and yet produce much the same effects, so it is probable, that what is the cause of earthquakes and subterraneous thundering, flashings, and violent expansion, as I may so call those phænomena observable in those *crises* of nature, may be in divers particulars differing from every one of these, both as to the materials, and as to the form and manner of ascension, and yet as to the effects, they may be very analogous and similar. So that though I cannot possi-

---

but too much resembles those natural calamities, whose causes we at present are endeavouring to investigate, as if the miseries of our condition were not enough, without this addition to them of our own contriving!

Gunpowder contains a large proportion of nitre, less of charcoal, and a very trifling quantity of sulphur. An hundred pounds of gunpowder possesses seventy-five pounds of nitre, fifteen of charcoal, and ten of sulphur. This mixture is triturated for ten or twelve hours in wooden mortars, with pestles of the same substance; and a small proportion of water is at the same time added. It is then passed through several skin sieves to be granulated. The granulated powder is next rested to separate the dust, and being then put into a cask by the motion of its parts, the cask being turned by a wheel, it becomes glazed, or polished. Chemists and natural philosophers have entertained various opinions concerning the violent explosion produced by gunpowder. Some have supposed it to arise from water turned into vapour, others to the sudden augmentation of the air. But Ingenhousz seems to have given the best explanation of the phœnomenon, which will be found hereafter exactly to correspond with the able conjecture of Hook.

The Abbé Fortana first discovered that an ounce of nitre gave out by the means of fire about eight hundred cubic inches of the purest oxygen air: also that an ounce of charcoal heated in a retort, gave out about an hundred and fifty cubic inches of inflammable air mixed with a small proportion of fixed air. Dr. Ingenhousz put together these two experiments, and calculated the quantity of gas extricated from a cubic inch of gunpowder at the moment of ascension, which must amount to five hundred and sixty-nine cubic inches of other elastic fluids. And as these must occupy four times this space at the degree of heat they must experience, hence it follows, that the air extricated from a cubic inch of gunpowder must occupy at least two thousand two hundred and sixty-six cubic inches. Besides this, the inflammable air unites with the oxygen air, and produces fresh heat, and vapour, and hence that quick and powerful expansion, pressing most where the resistance is least, and pursuing the ball in the cavity along which it runs. May not the inflammable air in part, arise from the water of crystallization in the nitre? as it forms one part, out of an hundred, in the producing of gunpowder. As to the sulphur, this appears to have no other use than the speedier and more certain ascension of the powder: for the poachers, says Mr. Robins, an ingenious writer, are in the practice of depriving powder of its sulphur by heating it with warm ashes in a tin plate; and they imagine that by this means the force of the powder is increased, and the arms less injured by use.

bly prove what the materials are, yet the effects speak them to be somewhat analogous to those of gunpowder, or *pulvis fulminans, aurum fulminans** or lightning, which, though they seem very differing in many particulars, yet when I come to shew the causes and reasons of those effects, I shall manifest, that it is but one operation in nature, and that which causes the effect in one causes the effect in all the rest; and the outward appearances of the differing materials, and the different way of operating, are nothing but the habits, and dresses, and visors of the actors, and the differing modes and postures by which they act their several parts, which, when they have done, they are at an end, and have exerted their whole power, and there must be a new set of actors to do the same thing again; the oil of the lamp will be turned all into flame, but you must have fresh oil, if you will have the flame continued. So the materials that make the subterraneous flame of fire, or expansion, call it by which name you please, is consumed and converted to another substance, not fit to produce any more the same effect; and if the conflagration be so great as to consume all the present store, you might safely conclude that place would no more be troubled with such effects; but if there be remainders, either already fit and prepared, but sheltered from ascension by other interposing incombustible materials; or that there be other parts not thoroughly ripe, and sufficiently prepared for such ascension, concurrence of after causes may repeat the same effects, and that *toties quoties* till all the mine be exhausted, which I look upon as a thing not only possible, but probable, nay, necessary, for that I find it to be the general method of nature, which is always going forward, and continually making a progress of changing all things from the state in which it finds them at the present; all things as they proceed to their perfection, so they proceed also to their dissolution and corruption, as to their proceeding estate; and where nature repeats the process, it is always on a new individual.

"It is very remarkable that the Isle of Modunda, which it seems is all an uninhabited rock, was split, and a part of it tumbled down and sunk into the sea; upon which occasion it seems it made a prodigious noise as of many cannon, and sending up at the same time a great cloud of dust, as they term it, which, in probability, was also mingled with smoke, which puts me in

---

* Gold is not attacked by the *sulphuric acid*, and is very slightly acted on by the *nitric acid*; but is attacked with most energy by the *nitro-muriatic* acid, or *aqua regia*, as it is called, and the *oxy-mu-*

mind of the Phænomena I observed lately, when the powder-mill and magazine at Hackney blew up; for besides the very great noise of the blow which I heard, being within a mile of it, in the fields, I observed immediately, a great white cloud of smoke to rise in a body to a great height in the air, and to be carried by the wind for two miles and better without dispersing or falling down, but perfectly resembling the white summer clouds: but this only by the bye. From these Phænomena of the earthquake it seems very probable, that it proceeded from such subterraneous inkindling as resembles gunpowder, both by the noise it yielded, and in the suddenness of its firing, and its powerful expansion when fired; for the noise was as of many cannon; this alone proves it to be very sudden.

" Next the splitting of the rocky island proves its power to be very great; this is proved yet farther by the blow and strokes it communicated to the sea, and so to the ships that sailed upon it; for no slow motion whatever could have communicated such a concussion through the water to the vessels upon it; but it must be as sudden as that of powder, otherwise the stroke of the earth upon the incumbent seas, would never have had the like success; for if it had been a gradual rising of the bottom, the sea would gradually have run off from it, and upon its sinking again have gradually returned, and the vessels on it would only have been sensible at most but of a current or running of the water to or from the place sinking or rising, somewhat like the effect that happened at Nevis; which doth plainly shew, that, besides the sudden strokes

---

riatic acid, which are the true solvents of gold. This solution yields yellow crystals, resembling topazes, in truncated octahedra, these crystals being a true MURIATE OF GOLD. It tinges animal substances purple, and by distillation, yields a red liquor, called by the adepts, *the red lion*. An OXIDE OF GOLD is precipitated from this solution, in a *yellow powder*, nearly in a metallic state, by *lime*, *magnesia*, and by *alkalies*; the precipitate being soluble in the *sulphuric*, *nitric*, and *muriatic acids*.

When precipitated by *ammoniac* from the yellow solution, it is called FULMINATING GOLD, it detonating when gently heated. Fulminating gold has been proved to be a mixture of ammoniac, and oxide of gold; the oxygen of the latter, and the hydrogen of the alkali taking fire by simple heat, detonate; and the gold is restored to its metallic state.

Nitriated silver, being precipitated from its solution, separated from the fluid, exposed three days to the air and light, and mixed with liquid ammoniac, becomes, when dry, FULMINATING SILVER. This exceeds in power, gunpowder, and even fulminating gold. Once obtained, it can no longer be touched without a violent detonation, no more than one grain being sufficient to give rise to a dangerous fulmination; after this fulmination, the silver is found reduced or revivified, its oxygen having combined with the hydrogen of the ammoniac, by which water, in the state of vapour, is produced. This water, instantly vaporized, and possessing all the elasticity, and expansive force of that state, is the principal cause of the phænomenon; in which the nitrogen of the ammoniac, with its whole expansibility, bears a part. Vide an excellent Compendium of Chemistry by the ingenious JAMES PARKINSON, surgeon.

or concussions, there was also a considerable rising and sinking of the whole island as to the level of the sea.

"But that which I principally note under this head is, that a good part of the said island tumbled down and was sunk into the sea, which gives an account how many parts of the earth come to be buried under ground and displaced from their former situations, and thence how ships' anchors, bones, teeth, &c. that have sometimes been digged up from great depths, may have come to be there buried.

"It is very remarkable also, that this eruption sent up into the air great clouds of dust and smoke, which for the most part must soon fall down again into the sea, or contiguous parts of the island. This will give a probable account how the layers of the superficial parts of the earth may come to be made; for the bigger part of this dust must come down to the bottom first, and settle to a certain thickness and make a bed of gravel, then will follow beds of coarse sand, then beds of finer and finer sand, and last of clays or moulds of several sorts; again much of that which fell upon the higher parts of the island, will, by the rivers, be washed down into the vales, and there produce the like beds or layers of several kinds, and so bury many of the parts that were before on the surface. Thus plants and vegetable substances may come to be buried, and the bones and teeth of the carcasses of dead animals: these may also sometimes be buried under beds or crusts of stone, when the parts that thus make the layers chance to be mixed with such subterraneous substances as carry with them a petrifying quality.

"What is most remarkable in these earthquakes in the Leeward islands, is, that they have all happened to places not far distant from the sea, or even under the sea itself, though the eruptions have been, for the most part on the land. So that there doth seem to be somewhat of reason to conjecture as *Signior Bottoni* in his *Pyrologia Topographica*, that the saline quality of the sea-water may conduce to the producing of the subterraneous fermentation with the sulphureous minerals there placed, which the experiment lately here exhibited at a meeting of this society, does yet make more probable; for by that it was evident, that the mixing of spirit of salt with iron, did produce such a fermentation as did produce a vapour or steam, which by an actual flame was immediately fired like gunpowder *, and if inclosed, would,

* This is the first account we have of the production of *inflammable air* (Hydrogen Gas).

in all probability, have had a like effect of raising and dispersing of those parts that bounded and imprisoned it. Now, it is evident that the melted matter which was vomited out of *Ætna* in the year sixty-nine (of which we have a part now in the repository) was very much like to melted or cast *iron*, and I doubt not but that there may be much of that mineral in it; besides, the foot of that mountain does extend even to the very *sea*, and in all probability may have caverns under the sea itself, which is argued also from the concurrency of the conflagration of *Strombolo* and *Lipary*, islands considerably distant by sea, at the same time, it is generally believed that there may be subterraneous cavernous passages between them, by which they communicate to one another; so that sometimes it begins in *Ætna*, and is communicated to *Strombolo*, and reciprocally to *Mongibel*.

" This possibly may afford a probable reason why islands are now more subject to earthquakes than continents and inland parts; and indeed how so many islands came to be dispersed up and down in the sea, namely, for that these fermentations may have been caused in the parts of the earth subjacent to the sea, which being brought to a head of ripeness, may have taken fire, and so have had force enough to raise a sufficient quantity of the earth above it, to make its way through the sea, and there make itself a vent, as that of the *Canaries* did in the year thirty-nine, which, if sufficiently copious, may produce an island as that did also for a time, though it hath since that time again sunk under the surface of the sea:* but the island of *Ascension*, which,

---

* The swallowing up of islands by Volcanos is, we suppose, represented by the story of PROSERPINE.

Thus in *Sicilia's* ever-blooming shade
When playful PROSERPINE from CERES stray'd,
Led with unwary steps her virgin trains
O'er *Ætna's* steeps, and *Enna's* golden plains;
Pluck'd with fair hand the silver-blossom'd bower,
And purpled mead,—herself a fairer flower;
Sudden, unseen amid the twilight glade,
Rush'd gloomy DIS, and seiz'd the trembling maid.
Her starting damsels sprung from mossy seats,
Dropp'd from their gauzy laps the gather'd sweets,
Clung round the struggling nymph, with piercing cries
Pursu'd the chariot, and invok'd the skies;—
Pleas'd as HE grasps her with HIS iron arms,
Frights with soft sighs, with tender words alarms,
The wheels descending roll'd in smoky rings,
Infernal *Cupids* flapp'd their demon wings;
Earth with deep yawn receiv'd the fair, amaz'd,
And far in night, celestial beauty blaz'd. DARWIN.

by all appearances, doth seem to have been the same way produced, doth still remain as a witness to prove this hypothesis.* A like testimony to this,

---

* New islands are formed in two ways; either suddenly, by the action of subterraneous fires; or more slowly, by the deposition of mud, carried down by rivers, and stopped by some accident. With respect particularly to the first, ancient historians, and modern travellers, give us such accounts as we can have no room to doubt of.

" On the twenty-fourth of May, in the year 1707, a slight earthquake was perceived at *Santorin*; and the day following, at sun-rising, an object was seen by the inhabitants of that island, at two or three miles distance at sea, which appeared like a floating rock. Some persons, desirous either of gain, or excited by curiosity, went there, and found, even while they stood upon this rock, that it seemed to rise beneath their feet. They perceived also that its surface was covered with pumice stones and oysters, which it had raised from the bottom. Every day after, until the fourteenth of June, this rock seemed considerably to increase; and then was found to be half a mile round, and about thirty feet above the sea. The earth of which it was composed seemed whitish, with a small portion of clay. Soon after this the sea again appeared troubled, and steams arose, which were very offensive to the inhabitants of *Santorin*. But on the sixteenth of the succeeding month, seventeen or eighteen rocks more were seen to rise out of the sea, and at length to join together. All this was accompanied with the most terrific noise, and fires which proceeded from the island that was newly formed. The whole mass, however, of all this new-formed earth, uniting, increased every day, both in height and breadth, and, by the force of its explosions, cast forth rocks to seven miles distance. This continued to bear the same dreadful appearances till the month of November in the same year; and it is at present a volcano which sometimes renews its explosions. It is about three miles in circumference, and more than from thirty-five to forty feet high." Hist. de l'Acad. an. 1708, p. 23.

It seems extraordinary, that about this place in particular, islands have appeared at different times, particularly that of Hiera, mentioned above, which has received considerable additions in succeeding ages. Justin tells us, that at the time the Macedonians were at war with the Romans, a new island appeared between those of Theramenes and Therasia, by means of an earthquake. We are told, that this became half as big again about a thousand years after; another island rising up by its side, and joining to it, so as scarce at present to be distinguished from the former.

The ancients who clothed in figure all the great phænomena of nature, represented this formation of islands, by the beautiful Fable of VENUS (who was wedded to VULCAN) rising out of the ocean,

Now, on her beryl throne by Tritons borne,
Bright rose THE GODDESS like the Star of Morn;
When with soft fires the mighty dawn he leads,
And wakes to life and love the laughing meads;—
With rosy fingers, as uncurl'd they hung
Round her fair brow, her golden locks she wrung;
O'er the smooth surge on silver sandals stood,
And look'd Enchantment on the dazzling flood,
The bright drops rolling from her lifted arms,
In slow meanders wander o'er her charms,
Seek round her snowy neck their lucid track,
Pearl her white shoulders, gem her ivory back,
Round her fine waist and swelling bosom swim,
And star with glittering brine each crystal limb.
—The immortal form enamour'd NATURE hail'd,
And BEAUTY blazed to heaven and earth *unveil'd*.

DARWIN.

of the cause and manner of their production, I take the island and pike of *Tenariff* to be, so *Hecla* of *Iceland,* so *Bearenberg* of *John Mayens* or *Trinity Island,* so *del Fuego* of the Icelands of *Cape Verd,* so *Ternate* of the *Moluccas*; and the island of *Mascarenas,* of the islands about *Madagascar* among the *Antillas* or *Caribes,* all which do seem to me to be remaining testimonies how, and in what manner, and by what means those other islands which have now worn out the marks of their first origination, were at first produced. And though the fires be extinct in many of the other islands, yet it is observable, that the prodigious high mountains or sugar-loaf pikes or hills do yet remain as marks of what they had been heretofore; so the pike of *Fayal* among the *Terceras,* and the whole island of St. *Helena,* and several others of those about *Madagascar* and of the *East Indies,* and of those of the *Antilles,* and that of St. *Martha* mentioned by *Dampier,* do seem to me to be plain evidences of the former and original causes of them all.

" Nor do I in the least doubt but that an inquisitive person who should purposely survey all other islands that wanted these marks or tokens of such eruptions, might find enough of other indications * to manifest by what means

---

* " Near Reading, in Berkshire, for many succeeding generations, a continued body of oyster-shells has been found through the whole circumference of five or six acres of ground. The foundation of these shells is an hard rocky chalk; and above this chalk, the oyster-shells lie in a bed of green sand, upon a level, as nigh as possibly can be judged, and are about two feet in thickness." (Phil. Trans. vol. ii. p. 427.)

These shells are in their natural state, but " they were found also petrified, and almost in equal abundance, in all the Alpine rocks, in the Pyrenees, on the hills of France, England, and Flanders. Even in all quarries from whence marble is dug, if the rocks be split perpendicularly downwards, petrified shells, and other marine substances, will be plainly discerned." (Buffon, vol. i. p. 407.)

About a quarter of a mile from the river Medway, in the county of Kent, after the taking off the coping of a piece of ground there, the workmen came to a blue marble, which continued for three feet and an half deep, or more, and then beneath appeared an hard floor, or pavement, composed of petrified shells crowded together. This layer was about an inch deep, and several yards over; and it could be walked upon as upon a beach. These stones, of which it was composed, (the describer supposes them always to have been stones) were either wreathed as snails, or bivalvular like cockles. The wreathed kinds were about the size of an hazle-nut, and were filled with a stony substance of the colour of marle; and they themselves, also, till they were washed, were of the same colour; but when cleaned they appeared of the colour of bezoar, and of the same polish. After boiling in water they became whitish, and left a chalkiness upon the fingers. (Phil. Trans. p. 426.)

In several parts of Asia and Africa, travellers have observed these shells in great abundance. In the mountains of Castravan which lie above the city Burat, they quarry out a white stone, every part of which contains petrified fishes in great numbers, and of surprising diversity. They also seem to continue in such preservation, that their fins, scales, and all the minutest distinctions of their make, can be perfectly discerned. (Buffon, vol. i. p. 408.)

they so came to be placed in the sea, so far from any part of the continents they are opposite to.

" Nor do I conceive they were all thus formed at once, but rather successively, some in one, some in other ages of the world, which may probably be in some measure collected from the quantity or thickness of the soil or mould upon them fit for vegetation; whence the island of *Ascension* may be rationally concluded to have been a production of not many ages, and the *Bermudas* also of not very many more, because of the thinness of such a soil. So also the island of *Barbadoes*, and some others, whose mould is yet but thin in respect of what it is in some others, and especially in those of greater magnitude and in the greater continents.

" Hereupon possibly it may be inquired why those greater islands and continents should be of greater antiquity than the smaller islands. To which I answer, that in the first ages of the world there were much greater magazines, or stores of the materials fitted for this purpose, which being first kindled threw up from under the sea, with which they were covered, vast quantities of it all at once, and thereupon those magazines became in a manner exhausted, yet not so totally as not to leave some smaller parcels of those substances so disposed, as not to be ready for inkindling together with those greater; besides there remained other smaller parcels of it disposed and placed in other parts of the globe sufficiently distant from them, not to be

---

This disposition of shells in strata indicate their origin as connected with the sea.

Other appearances, as the bones of elephants, and other large animals, prove the *general deluge*, and this instrument of destruction was exhibited, as a tremendous proof of the omnipotency of the CREATOR of all things, and of HIS judgments.

When man too long the paths of vice pursu'd,
THY hand prepar'd the *universal flood*;
" *Withdraw thy light, thou sun! be dark, ye skies;*
" *And from the deep abyss ye waters rise!*"
The *frighted angels* heard th' Almighty LORD,
And o'er the earth from wrathful viols pour'd
Tempest and storms, obedient to his word.
Mean time his Providence to *Noah* gave
The guard of all that he design'd to save:—
Exempt from general doom *the patriarch* stood,
Contemned the waves, and triumph'd o'er the flood.

PRIOR.

For the mode in which the *deluge* was produced, vide Note * page 111.

affected or inkindled at the same time, as those I have mentioned to have been the causes of the islands far distant from the continents.

"Nor do I conceive that all those clusters were all thrown up at once, as the *Grecian* islands in the *Archipelago*, the *East-Indian* Islands in that part called the *South Sea*, the *Maldivia* near the coast of *Malabar*, the islands scattered at the North of *Madagascar*, the islands to the south-west of *St. Helena* in the *Atlantic* ocean, *Finidada dos picos*, the isles of *Cape Verd*, *Canaries*, *Orcades*, &c. also the *Gallopegas* and others in the *Pacific Sea*, or *Mar del Zur*; but rather that some were made in one age, and some in other ages of the world. And this was timed as the several magazines came to be ripened and then fired; they only indicating, as I conceive, that in those places of the terrestrial globe, there were placed the proper mineral ferments or seeds as it were of them, which, when the convenient times were come and accomplished, then they were put into act, and then they produced their effects, which are the islands that now remain the lasting monuments of them. Nor can I suppose that all the magazines of the earth of this kind are blown up and spent, but that there may be many other yet remaining for the future ages to be made sensible of their effects." Such were the conjectures of Hook.

Since the discovery of the composition of water, and our present knowledge that carbonaceous substances decompose this element, setting free its inflammable air, and that most caverns are replete with this gas*, we

* In many of the chambers of coal-mines, notwithstanding the shafts, the *inflammable air* is so predominant that the colliers are obliged to work by the light of a machine, constructed of flints and iron, which a boy keeps turning, for this gas is not inflamed by the spark, like gunpowder, whereas it kindles in an instant from flame, and has often thus produced the most terrible destruction, before this invention of light from flint and steel was made by a steward of the late Earl of Lonsdale. The inflammable gas mixed with a certain proportion of atmospheric air may be breathed with impunity. That undaunted aerinaut Pilatre de Rozier, before a large company at Paris, inhaled it pure, and emitting it from his nostrils and mouth in the dark, set fire to the air in its passage, and realized the fabulous account of Cerberus, who is represented as vomiting out fire. Once attempting to mix it with one-ninth part of atmospheric air, and then setting it on fire, so terrible an explosion was produced, that he imagined all his teeth had been driven out. As to mixed hydrogenous air we have the authority of Spallanzani.

"On this plain it was, that, formerly, stood the furnaces on which the sulphur of Vulcano was purified. But this useful labour had been long since abandoned, and even prohibited, from the supposition that the vapours arising from the purgation of the sulphur were prejudicial to the plantations of vines in Lipari. A few years ago, indeed, it was again resumed, by the special permission of his Sicilian Majesty; but was soon again given up, not because any fear was then entertained that the vines would be injured, which the more judicious of the natives of Lipari are now convinced is a vulgar error, since they sustain no damage from the smoke of the crater of Vulcano itself, though that is beyond all comparison more in quantity than that produced by the purification of the sulphur: nor was it abandoned because the quantity of sulphur obtained was too little to repay the trouble and expence, as the vein

are at no loss to suppose the production of this aerial body arising from the sea-water when it has forced its way through the sides of the volcanic cavern.

---

is very rich and even inexhaustible; for wherever the ground about the craters of Vulcano and Vulcacanello is but slightly turned, fine clods of sulphur are found; which are larger and more numerous the deeper the earth is dug into. My own observations have in this particular sufficiently confirmed the testimony of the people of Lipari: as I was convinced, in my different visits to the island, that in the very places from which the sulphur had been extracted, after a short time it is re-produced.

"The real cause why the inhabitants of Lipari no longer continued this work was, that the ground, which on the surface is more or less warm, grows hotter the deeper it is dug into, and, at the depth of five or six feet, becomes so hot as to be almost insupportable; to which is to be added the offensive stench of the sulphureous fumes that issue in great abundance from these excavations. If this mineral was once extracted here to great advantage, as we are assured by history, it seems certain that these difficulties could not then exist.

"Continuing my journey towards the south from these forsaken furnaces, and having mounted a short but steep ascent, a second, but a much more spacious plain opened before me, which was every where sandy, except that a few erratic lavas were thinly scattered over it. Beyond it rose a considerable eminence, which when I had ascended, the noblest spectacle Vulcano can offer presented itself to my view, I mean its crater. Except that of Etna, I know none more capacious and majestic. It exceeds a mile in circuit, the mouth is oval, and its greatest diameter is from the south-east to the west. This mountain externally has the form of a direct cone, and its crater that of a cone inverted. The height of the internal sides from the bottom to the top is more than a quarter of a mile. From the top, the bottom may be seen, which is flat, and from many places in it exhale streams of smoke, that rise above the crater, and emit a sulphureous odour which may be perceived at a considerable distance.

"After having made the circuit of the upper circumference of the crater, I became desirous to enter it, and descended to the bottom, to examine the internal parts; the southern side, which is not very steep, appearing to invite to such examination. I was not willing however to undertake such an adventure alone, but wished for some one to accompany me, who might serve me as a guide, and, I may likewise add, who might keep up my courage. But my wishes were vain. The four sailors who had worked the boat which brought me to the island, and had gone with me to the edges of the crater, when they found I entertained thoughts of going down into it, positively refused to follow me, alledging the evident danger to which I should be exposed, and adducing the example of I know not what traveller, who, a few years ago, having descended into this deep gulph, paid for his temerity by never coming out again. All my entreaties, therefore, and all offers of reward were fruitless; and I was obliged to return to Lipari without having been able to gratify my wish. These sailors were natives of Lipari, nor could I find any of their countrymen who would hazard accompanying me in making this experiment. So great is the dread they are inspired with by this volcano, proceeding, probably, from the fame of its ancient terrors, and also from some recent eruption, of which we shall hereafter have occasion to speak.

"A resolute Calabrian, who had been banished to Lipari for some crime committed at Naples, was the only one, who, with the permission of the Marchese Chiavelli, the governor of that city, and the promise of a large reward, could be induced to go down with me into the crater. We descended on the 13th of September 1788. I have already said that the sides towards the south-east are not very steep, and on this side we therefore safely reached the bottom, where I proceeded to make such observations as I thought of most importance. I here perceived, more distinctly than I could above, that the crater was a hollow cone reversed, but truncated by the bottom on which I stood. The sides, except in that part where we descended, are every where inaccessible. As they are covered with sand, they are marked with deep furrows which are the effect of rains.

"The bottom on which we stood, may be about somewhat more than the third of a mile in circumference. It is covered with sand, like the sides, and in form an oval. I soon perceived that it could not be walked over without danger, and that it was necessary to use the greatest circumspection in examining it. I have already mentioned the subterranean noise heard on approaching the crater of

The muriatic acid of the sea-water also meeting with sulphur * is converted into the sulphuric acid, which in a diluted state, acts upon iron, and thus

---

Vulcano. Here it may be said to be about a hundred times louder. Under this bottom we seem to hear a river running, or rather a conflict of agitated waves which meet, and impetuously clash together. The ground, likewise, in some places, cleaves in cracks, fissures and apertures, from which hissing sounds issue resembling those produced by the bellows of a furnace. I therefore thought there was every reason to conclude, that these sounds are occasioned by an elastic gas which issues through those fissures; and was afterwards perfectly convinced of the truth of this supposition by the following facts. If the hand be approached to any of these apertures, a strong impression is felt of an extremely subtle invisible fluid; and, if a lighted candle be applied to them, it will, it is true, be frequently extinguished by the impetus of the fluid, but sometimes it will set fire to the fluid itself, producing a flame of a bluish red colour which lasts for several minutes. The fetid odour which is then perceived convinced me that it is a *sulphurated hydrogenous gas*." Vide Travels in the Two Sicilies, &c.

* Sulphur is extracted from pyrites, an ore common to many parts of the world, and it is also found mixed with different earths, but is only met with in its pure state in the neighbourhood of volcanos, or as deposited by springs strongly impregnated with sulphur. All France, and great part of Europe, is furnished with sulphur from the mines of Solfatara in Italy, where the earth is found most to abound with this mineral.

The valley of Salfatara, near Naples, seems to exhibit, in a minute degree, whatever is seen of this horrible kind on the great theatre of nature. This plain, which is about twelve hundred feet long, and a thousand broad, is embosomed in mountains, and has in the middle of it a lake of noisome blackish water, covered with a *bitumen*, that floats upon its surface. In every part of this plain caverns appear smoking with sulphur, and often emitting flames.

This famous mine is an oval plain, the greatest diameter of which is about four hundred yards, raised about three hundred yards above the level. Almost all the surface is bare and white, like marle; and is every where sensibly warmer than the atmosphere in the greatest heat of summer; so that the feet of persons walking there are burnt through their shoes. It is impossible not to observe the sulphur there; for every where may be perceived by the smell a sulphureous vapour, which rises to a considerable height, and gives reason to believe that there is a subterraneous fire below, from which that vapour proceeds. Near the middle of this field there is a kind of bason three or four feet lower than the rest of the plain, in which a sound may be perceived when a person walks on it, as if there were under his feet some great cavity, the roof of which was very thin. After that, the lake Agnano is perceived, whose waters seem to boil. These waters are indeed hot, but not so hot as boiling water. This kind of ebullition proceeds from vapours which rise from the bottom of the lake, which being set in motion by the action of subterranean fires, have force enough to raise all that mass of water. Near this lake there are pits, not very deep, from which sulphureous vapours are exhaled. Finally, there are some deeper excavations, whence a soft stone is procured which yields sulphur. From these cavities vapours exhale, and issue out with noise, and which are nothing else than sulphur subliming through the crevices. This sulphur adheres to the sides of the rocks, where it forms enormous masses: in calm weather the vapours may be evidently seen to rise twenty-five or thirty feet from the surface of the earth. These vapours, attaching themselves to the sides of rocks, form enormous groups of sulphur, which sometimes fall down by their own weight, and render these places of dangerous access. In entering the Solfatara, there are warehouses and buildings for the refining of sulphur. Under a great shed, or hangar, supported by a wall behind, open on the other three sides, the sulphur is procured by distillation from the soft stones we mentioned above. These stones are dug from under ground; and those which lie on the surface of the earth are neglected. These last are, however, covered with a sulphur ready formed, and of a yellow colour; but the workmen say they have lost their strength, and that the sulphur obtained from them is not of so good a quality as the sulphur obtained from the stones which are dug out of the ground. These last-mentioned stones are broken in lumps, and put into pots of earthen-ware, containing each about twenty pints, Paris measure. Vide Macquer's Chemical Dictionary.

liberates a still larger quantity of the inflammable air:* or robbing the metallic oxyds of their oxygen is converted into the oxygenated muriatic acid, which has the property to form with potash, a salt, which rapidly kindles hot inflammable matter, and produces the purest *vital air* known. When these two airs are in great abundance in the hollow caverns of the earth bordering on the sea, and this *aerial gunpowder* * gets kindled, which may arise either

---

In the West Indies, on the island of Guadaloupe, is a hill called La Soufriere, or the Mountain of Sulphur, which rises to a great height; the top of it is bare, nothing growing upon it but fern, and some sorry shrubs laden with moss; but it affords a fine view of Dominica, Mariagalante, Martinico, Montserrat, Nevis, and the other neighbouring islands. Upon the highest part is a rugged platform, covered with burnt stones of all sizes; and from several clefts and chinks issue smoke. On the east side are two mouths, which open into a pit of sulphur, one of which is an oval hole of about an hundred feet in its greatest diameter, out of which also frequently arise thick clouds of black smoke, accompanied with sparks of fire. The negroes who sell brimstone fetch it from this mountain. About two hundred paces below the lowest of these mouths are three pools of very hot water, four or five paces from one another: the water of the largest is very dark coloured, and smells like that in a smith's forge: the second is whitish, and has the taste of allum: the third is blue, and has a vitriolic taste.

The Marquis Ippolito, in his letter to Sir William Hamilton, which he published, relates, that immediately after the late earthquake, the waters of a well in Maida (one of the towns overthrown) of which the inhabitants used to drink, became of so strong a sulphureous taste, that it was impossible to smell to it.

* *Hydrogenous gas*, or *inflammable air*, may be extracted from all bodies in which it is a constituent part; but the purest is that afforded by the decomposition of water. For this purpose the sulphuric acid diluted with water, is poured upon iron, or zinc; and the water, which serves as a vehicle for the acid, is decomposed on the metal; its oxygen combines with it, while the hydrogenous gas escapes. This explanation, however contrary to the ancient notion, is not the less a demonstrated truth; in fact, the metal exists in the state of an oxyd in its solution by the sulphuric acid, as may be proved by precipitating it with pure vegetable alkali: on the other hand, the acid itself is not at all decomposed; so that the oxygenous gas cannot have been afforded to the iron but by the water. Water may be decomposed likewise still more directly by throwing it upon iron strongly heated; and hydrogenous gas may be obtained by causing water to pass through a tube of iron ignited to whiteness.

* Hook, as we saw, was the first to conjecture, that volcanic explosions arose from certain combinations resembling gunpowder, and that this might arise from an aerial product. His conjecture has been since amply verified, and an *aerial gunpowder* has been employed in lieu of solid forms, liberating glasses.

Fig. 18th, represents a small pistol, necessary to shew the force of exploding inflammable air. Since these instruments were introduced, their form has been very much diversified; some having been made of brass, and so large as to drive a leaden bullet; others have been made of tin, &c.; but that shewn by this figure is of glass, and so simple, that it may be easily constructed, even by persons of no great genius; and gives a sufficient idea of the power of exploding inflammable air, by driving a cork to a considerable distance.

ABD is a strong glass tube five inches long, and about half an inch in diameter. Into the inside of this tube, and towards one extremity of it, a small slip of tinfoil CB is pasted, so as to be about two inches within the tube, and be turned on the outside of it at B. Into this same extremity BD the small wire GH, knobbed at its extremity H, must be cemented very fast. The best method is to cement the wire into a small glass tube F, and then to wrap some cotton on thread round this small tube, and to cement it into the extremity BD of the pistol. The end G of the wire should be bent towards the slip of tinfoil C, so as to come within about one tenth of an inch of it. Now when this

from the accension of those highly inflammable matters, called bitu-

---

pistol is required to be charged, the inflammable air should be kept in a corked bottle, to the mouth of which the aperture A of the pistol must be applied very closely, in the same moment that the cork is removed, keeping the pistol inverted over it. In this case it is plain, that the common air, which is in the pistol, will mix with the inflammable air, because the former being heavier than the latter, will descend into the bottle, &c. When the pistol has been thus kept over the bottle for about ten or fifteen seconds, it must be removed, and both the pistol and the bottle must be instantly corked. If now this charged pistol be held by applying the thumb and fingers to the lower part of it, so as to touch the tinfoil B, and an electric spark be given to the knob H, by approaching it to the prime conductor of an electrical machine, or to the knob of a small charged electric phial, the inflammable air in the pistol will be fired by the spark, which will necessarily pass between G and the tinfoil C, and will drive the cork I to a considerable distance. The above-mentioned bottle filled with inflammable air is sufficient to charge the pistol several times successively, without being again filled with inflammable air, especially if it is pretty large; only it should be minded, that when the pistol has been filled out of the same bottle several times, the inflammable air in that bottle becomes mixed with a good deal of common air, for which reason the pistol should then be kept some time longer upon the bottle, in order to charge it. Sometimes the pistol will not explode, which is owing to its having been kept too long over the bottle, so as to become filled entirely with inflammable air; the common air contained in it being descended into the bottle in consequence of its greater specific gravity.

Fig. 19th, represents a brass pistol for inflammable air, which is more commonly sold at the philosophical instrument shops. It is here represented as transparent, in order to shew its internal construction. It consists of a brass chamber ABC, to the mouth of which A a cork is fitted. To the bottom of it a perforated brass piece is screwed, into which a glass tube DE is cemented, and into this tube is cemented a wire GF, furnished with a knob F at one end, and bent at the other extremity, so as to come within about one or two tenths of an inch of the brass piece. Fig. the 20th, shews this brass piece separate, and also the brass cap I, which, when the pistol is not used, is screwed at H, in the manner shewn by the dotted line, and serves to defend the tube E. This pistol is charged and discharged in the same manner as the glass one described above, but, being much larger, it requires a greater quantity of inflammable air, and consequently makes a greater explosion.

It is easily comprehended, that in the pistols described above, there cannot be introduced a mixture of inflammable and common air in any required proportion, much less can there be introduced a mixture of inflammable and oxygen air. In order to avoid this great inconvenience, Dr. Ingenhousz contrived another pistol, into which any required mixture of elastic fluids may be introduced. This pistol, and its separate parts, are exhibited in fig. the 21st, plate II. A *a* is the barrel of the pistol. B is the box or chamber for the elastic fluids. *b* the place where the barrel is screwed to the box. C the handle of the pistol. D is the wire or handle of the piston LK, the lower part of which, *hh*, is made square, in order to prevent its turning round. E is a hole on the side of the box, which is occasionally shut, by screwing the small nut *e* in it. F is a piece of brass with a female screw, which is fixed to the wooden handle by means of three strong screws, and to which the lower part *f* of the box is screwed. G is a piece of ivory fixed to the piston with a conical ivory termination L, which fits the conical end of the box. M. is the perforation in the wooden handle, through which the brass wire D passes. N is a small brass ball at the extremity of a wire, which passes through the canal R in the ivory cone. O is another piece of wire which passes through another hole, and touches the brass under the ivory piece. The wires are both fixed into the holes by means of the cement mentioned above. P is the small interval between the extremities of the two wires, through which the electric spark passes, when given by means of a charged electrical bottle to the ball N.

When the parts of this pistol are put together, as shewn by ABCD, the piston is pulled back, so as its part K may be at F, and the box is filled with inflammable and respirable air; the electric spark given to the small brass ball, as mentioned above, will inflame the gas, and its force will push a bullet, which is previously fixed into the barrel just where this is screwed to the box. But in order to charge the pistol with a mixture of inflammable and common air, or inflammable and oxygen air, in

mens * from the oxygenated marine acid, or from the kindling influence of

---

any required proportion, the piston must be pushed towards the conical part of the pistol, then unscrewing the barrel, the aperture of the pistol is applied to the neck of the bladder containing the mixture of inflammable and common or oxygen air, and drawing back the piston, that mixture of elastic fluid is introduced into the chamber or box of the pistol. This done, the bladder is detached from the extremity of the pistol, and at the same time a small leaden bullet, wrapped up in soft leather, is applied to the said aperture, and the barrel is screwed over it; thus the pistol is *charged*, and is now ready to be fired. Vide Cavallo on the different factitious airs.

* The *bitumens* generally taken notice of by writers on Natural History are, with respect to their consistence, either as fluid as oil, or as thick and tenacious as tar, or quite solid. The fluid bitumens are two, naptha, and petroleum, or rock-oil. These are oils which differ from each other in colour and consistence, and some other properties; the naptha is pale, light, and very inflammable; the petroleum is yellow, brown, or blackish, heavier and less inflammable than naptha: its difference from the naptha is attributed to its containing a greater quantity of acid in its composition. Both these oils are found in many parts of the globe, either floating on spring water, or dripping from the crevices of rocks. Mineral pitch is a bitumen which differs from petroleum in being thicker, heavier, and more glutinous; it was formerly found in the environs of Babylon, and constituted, according to Vitruvius, when mixed with lime, the cement which was used in building the walls of that city. At present it is met with in several parts of Europe, and in America, where it drips from rocks, and is called by us Barbadoes tar: it has a very offensive smell, and great tenacity, and is called by the inhabitants of Auvergne, in France, where it exudes from the earth, and sticks to the feet, devils dung. The asphaltum, or Jews pitch, is a bitumen much resembling mineral pitch; it is thrown up in a liquid form from the bottom of the lake where Sodom and Gomorrah stood, otherwise called the Dead Sea, or the lake Asphaltes, from a Greek word denoting a bitumen. This lake in the time of Esdras yielded bitumen—"*remember what I did to Sodom and Gomorrah, whose land lieth in clods of pitch.*" The bitumen floating upon the surface of the salt water, is condensed by the heat of the sun into a solid form, and is gathered by the Arabs on the shore where it is thrown. It is said to be the same substance which the Egyptians used in embalming their mummies, and it was called by them mummia mineralis. This bitumen has been found in many places of Asia and Europe, as well as on the shores of the Dead Sea; all that we meet with in the shops, is either an artificial composition, or an European asphaltum, the eastern ones being seldom brought into Europe, but used by the natives either as pitch for their ships, or as an ingredient in varnishing, or dying wool.

There is a very curious experiment which illustrates the relation which these four bitumens bear to each other. The most transparent oil of turpentine, resembling naptha, may be changed into an oil resembling petroleum, by mixing it with a small portion of the acid of vitriol; with a larger proportion of the acid, the mixture becomes black and tenacious, like Barbadoes tar; and the proportions of the ingredients may be so adjusted, that the mixture will acquire a solid consistence, like asphaltum. This experiment teaches us to conclude that naptha, petroleum, Barbadoes tar, and asphaltum, differ chiefly from each other, with respect to the quantity of acid which enters into their composition; and the substances procured by distilling pitcoal, or resinous vegetables, may furnish no improbable conjecture concerning the origin of these bitumens.

Let us suppose then a subterraneous fire to be situated in or near a stratum of pitcoal, of turf, of fossil wood, or of any other such bituminous matter; it is manifest that the inflammable air, and the different kinds of oils, which were collected by distilling small portions of these substances, would be elevated by the heat into the crevices of the superincumbent strata; the light and pale oil would be a sort of naptha, or petroleum, the black and tenacious oil would be a Barbadoes tar, and this might be so dried by the heat as to become an asphaltum. The oils not being miscible with water, would be found floating upon its surface, as it issued out of the bowels of the earth, and being very inflammable, might constitute burning wells, such as have been met with near Wigan, at Brosely, and in many other places: or where the oil did not meet with water, or was too heavy to float on it, we may conceive that it would impregnate the porous strata of several kinds of stones and earth. It has been

the electric fluid,* when an explosion takes place, and if the vent be sufficient from the open crater of the agitated volcano, an earthquake is avoided,

---

observed in another place, that they formerly obtained a sort of tar from a stone at Broseley; and the stratum which is called shale in Derbyshire, is so strongly impregnated with oil, that it will burn of itself, when set on fire: the workmen in digging through the black stone, which is incumbent on the shale, sometimes meet with cavities containing a thick black oil, which has oozed out of the surrounding stone. One of the greatest soughs, or subterraneous passages, which has, perhaps, ever been formed in great Britain, is that which is called Hell-car sough, in Derbyshire; this sough is driven through a stratum of shale, and the workmen are much troubled with *inflammable air,* which generally breaks into the sough, through the same crannies which give passage to little streams of water; they secure themselves from the air, by keeping great fans constantly in motion; for the inflammable air, being lighter than common air, floats near the roof of the sough, and being drawn down from thence, and mixed with the common air by the motion of the fans, it is circulated in the sough without danger. I am sensible that inflammable air may be produced by various other ways, as well as by the application of heat, to bituminous strata; but as bitumens do yield this air by distillation, it is probable enough, that such as is met with in bituminous strata, may sometimes, at least, be referred to the action of fire, situated, perhaps, at too great a distance from the surface of the earth to produce any other sensible effect. Vide the Bishop of Llandaff's very amusing and instructive CHEMICAL ESSAYS.

In the Duchy of Modena in Italy, there is a remarkable rock, which confirms very much the notion of oils and pitchy substances being separated from bitumens by a kind of subterraneous distillation. The inhabitants of the district, by piercing the sides of this rock, at different distances from its summit, obtain oil of different natures, thickening and growing heavier and deeper coloured, as the canals through which they flow approach to the surface of the earth; at the distance of a few feet below the surface of the earth, they find a very thick oil, which in digging deeper becomes soft as butter, and at still a greater depth, it is found to be as solid as pitch.

Near Derbens, on the Caspian Sea, there are springs of naptha, which Kempfer visited about a century ago, and of which he has left a description.

There is a place known by the name of the Perpetual Fire, where the fire burns without ceasing. The Indians do not attribute the origin of this inextinguishable fire to naptha; but they maintain that God has confined the Devil in this place, to deliver man from him. They go in pilgrimage thither, and make their prayers to God that he will not suffer this enemy of mankind to escape.

The earth impregnated with naptha is calcareous, and effervesces with acids; it takes fire by the contact of any ignited body whatever.

This perpetual fire is of great use to the inhabitants of Baku. They pare off the surface of this burning soil, upon which they make a heap of limestones, and cover it with the earth pared off; and in two or three days the lime is made.

The inhabitants of the village of Frogann repair to this place to cook their provisions.

The Indians assemble from all parts to adore the Eternal Being in this place. Several temples were built, one of which is still in existence. Near the altar there is a tube inserted in the earth, two or three feet in length; out of which issues a blue flame, mixed with red. The Indians prostrate themselves before this tube, and put themselves into attitudes which are exceedingly strange and painful.

Concerning the accension of different bodies by the mineral acids, vide note * page (102).

* The observations made by Sir William Hamilton on the last tremendous eruption of mount Vesuvius, shew how much the *electric fluid* is concerned in volcanic explosions.

" The black smoke of ashes, says this author, issuing continually from so many new mouths or craters, formed an enormous dense body of clouds over the whole mountain, and which began to give signs of being replete with the electric fluid, by exhibiting flashes of that sort of zig-zag lightning, which, in the volcanic language of this country, is called *ferilli,* and which is the constant attendant on volcanic eruptions.

During thirty years that I have resided at Naples, and in which space of time I have been witness to many eruptions of Vesuvius, of one sort or other, I never saw the gigantic clouds above-mentioned

and we have then only those natural fireworks, which as much surpass the imitated, as heaven is higher than the earth, but which impart a dreadful fear to the astonished inhabitants of those countries, where such tremendous scenes are carried on.

Hence in opposition to Dr. Darwin, but with a becoming deference, we conclude, that as in our frames a continued combustion is going on productive of *animal heat,** the sine qua non of life, and sensation, so there is a

---

so replete with the electric fire, except in the two great eruptions of 1767 and 1779. The electric fire, in the year 1779, that played constantly within the enormous black cloud over the crater of Vesuvius, and seldom quitted it, was exactly similar to that which is produced, on a very small scale, by the conductor of an electrical machine communicating with an insulated plate of glass, thinly spread over with metallic filings, &c. when the electric matter continues to play over it in *zig-zag* lines, without quitting it. I was not sensible of any noise attending that operation in 1779, whereas the discharge of the electrical matter from the volcanic clouds during this eruption, and particularly the second and third days, caused explosions like those of the loudest thunder, and, indeed, the storms raised, evidently by the sole power of the volcano, resembled, in every respect, all other thunder-storms, the lightning falling and destroying every thing in its course.

Out of these gigantic and volcanic clouds, beside the lightning, both during this eruption and that of 1779, I have, with many others, seen balls of fire issue, and some of a considerable magnitude, which, bursting in the air, produced nearly the same effect as that from the air-balloons in fire-works, the electric fire which came out having the appearance of the serpents with which those firework balloons are often filled. The day on which Naples was in the greatest danger from the volcanic clouds, two small balls of fire, joined together by a small link like a chain-shot, fell close to my casino at Posilipo; they separated, and one fell in the vineyard above the house, and the other in the sea.

The Abbé Tata, in his printed account of this eruption, mentions an enormous ball of this kind which flew out of the crater of Vesuvius while he was standing on the edge of it, and which burst in the air at some distance from the mountain; soon after which he heard a noise like the fall of a number of stones, or of a heavy shower of hail."

After the eruption had ceased, when Sir William Hamilton ascended the mountain, he thus writes, " While we were on the mountain, two whirlwinds, exactly like those that form waterspouts at sea, made their appearance; and one of them, which was very near us, made a strange rushing noise, and having taken up a great quantity of the fine ashes, formed them into an elevated spiral column, which, with a whirling motion, and great rapidity, was carried toward the mountain of Somma, where it broke, and was dispersed. As these were evident signs of an abundance of electricity in the air at this time, I have no doubt of this having been also an electrical operation."

* The ingenious Dr. Crawford appears to have been the first who attempted to ascertain by direct experiments the cause of ANIMAL HEAT as dependant upon the air. In an elaborate work he maintains, that the blood, which is returned to the lungs, is highly charged with *phlogiston,*—that the air having a greater affinity for *phlogiston* than the blood, attracts to itself *that principle,* and having in consequence a less *capacity* for heat than before, it parts with a portion of its heat,—and as the *capacity* of blood for heat is at the same time increased by the separation of the *phlogiston,* the *heat,* detached from the air, is fixed in a quiescent or latent state in the blood:—and that the blood in the course of the circulations absorbing *phlogiston,* and thereby having its *capacity* for *heat* diminished, part of it (in proportion to the quantity of *phlogiston* absorbed) breaks out in the form of sensible or moving heat, and hence the cause of ANIMAL HEAT.

It required a very strong philosophic conviction in any one to depart from a proposition at that time so generally received. But having made many experiments, when enquiring into this subject, Dr.

continued fermentation going on in the bowels of the earth, liberating fire

---

was confident, that the OXYGEN AIR which WAS ABSORBED BY THE BLOOD (as is proved in Sect. VI.) was the true source of ANIMAL HEAT. Struck with the important discovery, he proposed it as the subject of his *thesis* at Cambridge. The professors of physic and of chemistry were pleased at the *novelty* of the opinion, and very politely consented to his disputation on that question, so that Dr. THORNTON first maintained at Cambridge, previous to his receiving his degree in physic in that university, in opposition to the opinion of Dr. Crawford, " that the *venal* blood in the lungs absorbs from " air not *fire*, but *oxygen*, in combination with *the matter of heat* (OXYGEN AIR), and that in the " circuit of the blood through the body, the *oxygen*, meeting with some superior attraction, is divorced " from its *caloric*, (the matter of heat), which becoming disengaged *just as an acid discovers its sen-* " *sible properties, its alkaline basis being withdrawn from it),* so did it assume its well known " *active* character; and as *uncombined fire* ever tends to form an equilibrium, or equal temperature " with the substances around, by pervading the body, it became the source of VITAL or ANIMAL " HEAT."

Animal heat, therefore, appears to be a *gentle combustion:*—and *an animal* in many respects may be compared to a *burning lamp*; the HEAT produced in both cases arising from the *same cause.*

If AN ANIMAL be placed in *an exhausted receiver* of an air pump it quickly expires; in similar circumstances A BURNING LAMP goes out. If AN ANIMAL be not supplied with *fresh air* it dies, and its *heat* is extinguished; so it is with the LAMP. The air breathed by ANIMALS is *diminished in quantity*; so it is by the burning of THE LAMP. A *certain quantity* of air supports AN ANIMAL for a *certain time,* but no longer; so it will keep up the FLAME OF THE LAMP, for a *certain* time only. The air in which a LAMP has burnt out *destroys* ANIMAL *life*; so the air that THE ANIMAL hath breathed, *puts out* THE LAMP. Fixed, azotic, and inflammable airs, *destroy* ANIMALS; so likewise do they *extinguish* THE LAMP.

A LIVING ANIMAL and a BURNING LAMP, therefore, exactly agree in requiring the *same kind of air* to support them, and in producing *the same effects* upon the air, to which they are exposed.

But they do not resemble each other only in *producing* HEAT, *and requiring the same kind* of AIR: for if AN ANIMAL hath not *fresh supplies* of FOOD, as well as AIR, after a *certain time* it dies, and becomes cold; just in the same manner as THE LAMP dies out, if not *duly supplied* with OIL.

Since then *that part* of the air destroyed by RESPIRATION is the *same* as *that* destroyed by COMBUSTION; and since the *ultimate effect* is the *same* in both operations, that is, THE PRODUCTION OF HEAT, is it not reasonable to think, that the FOOD affords to the ANIMAL *principles alike attractive of* OXYGEN, *and disengaging* HEAT, as the OIL affords to THE LAMP? For since *the effects* are the same, *the cause* must be so too. OIL, therefore, *affords the principle attractive of* OXYGEN to THE LAMP: and, consequently, THE FOOD of animals *supports the generation of heat,* by *supplying to the animal body those principles which are attractive of* OXYGEN, *the base of vital air.*

The *chemical analysis* of such substances as are to support animal life confirms this opinion; for no substance affords proper nourishment, which contains not principles that readily combine with OXYGEN; and the instantaneous support, and refreshment, perceived by those, who are much exhausted, upon taking into the stomach certain inflammable substances, as diluted spirits, &c. depend upon the same principle. *Very different matters,* therefore, will support ANIMAL LIFE, if they contain principles, separable by the animal process, that have an affinity with *oxygen.*

To prove that *animal heat* arises from the *decomposition* of VITAL AIR by those substances which attract *oxygen,* we have the following very striking fact.

Dr. Beddoes, the justly celebrated professor of chemistry at Oxford, respired at times for seven weeks air of a much higher than the ordinary standard, and commonly such as contained almost equal parts of oxygen and common air. He relates, in his letter to Dr. Darwin, " that he felt that agreeable " *glow,* and lightness of the chest, which has been described by Dr. Priestley and others. In no long " time," he says, " I observed in myself a remarkable power of sustaining *cold.* Except one or two " evenings I never once experienced the sensation of *chilliness,* though cold easterly winds prevailed, " during great part of the time I inspired the *super-oxygenated air.* I was not only able," he adds,

from its various component parts, obeying the laws of attraction,* and that

---

" to reduce my bed-clothes to a single blanket and coverlid, but slept without inconvenience in a large " bed-chamber, looking to the north-east, with the window open all night, and with the door and " windows of an adjacent sitting room also open.—My appetite was keen, and I eat *one third* or *one " fourth more than before,* without feeling the stomach loaded."

Animal heat, therefore, proceeds from the chemical union of certain parts of our food and oxygen, modified, and combined, by the proper exercise of the natural animal functions, disengaging caloric. Vide The Philosophy of Medicine: or, Medical Extracts on the Nature of Health and Disease, including the Laws of the Animal Œconomy and the Doctrines of Pneumatic Medicine.

* The Supreme Being has given a force of mutual attraction to the parts of matter; a principle which is alone sufficient to produce that arrangement which the bodies of this universe present to our observation. As a very natural consequence of this primitive law, it follows that the elements of bodies must have been urged towards each other; that masses must have been formed by their re-union; and that solid and compact bodies must have insensibly been constituted; towards which, as towards a centre, the less heavy and less compact bodies must gravitate.

This law of attraction, which the chemists call Affinity, tends continually to bring principles together which are disunited, and retains with more or less energy those which are already in combination; so that it is impossible to produce any change in nature, without interrupting or modifying this attractive power.

Affinity is exercised either between principles of the same nature, or between principles of a different nature.

We may, therefore, distinguish two kinds of affinity, with respect to the nature of bodies.

1. The Affinity of Aggregation, *or that which exists between two principles of the same nature.*

2. The Affinity of Composition, *or that which retains two or more principles of different natures in a state of combination.*

OF THE AFFINITY OF AGGREGATION.

Two drops of water which unite together into one, form an aggregate, of which each drop is known by the name of an integrant part.

An *aggregate* differs from a *heap*; because the integrant parts of this last have no perceptible adhesion to each other; as, for example, a heap of barley, of sand, &c.

An aggregate, and a heap, differ from a *mixture*; because the constituent parts of this last are of a different nature; as, for example, in gunpowder.

The affinity of aggregation is stronger the nearer the integrant parts approach to each other; so that every thing which tends to separate or remove these integrant parts from each other, diminishes their affinity, and weakens their force of cohesion.

Heat produces this effect upon most known bodies: hence it is that melted metals have no consistence. The caloric, or matter of heat, by combining with bodies, almost always produces an effect opposite to the force of attraction; and we might consider ourselves as authorised to affirm that it is a principle of repulsion, if sound chemistry had not proved that it produces this effect only by its endeavour to combine the bodies, and thereby necessarily diminishing their force of aggregation, as all other chemical agents do. Besides which, the extreme levity of caloric produces the effect that, when it is combined with any given body, it continually tends to elevate it, and to overcome that force which retains it, and precipitates it towards the earth.

The mechanical operations of pounding, of hammering, or of cutting, likewise diminish the affinity of aggregation. They remove the integrant parts to a distance from each other; and this new disposition, by presenting a less degree of adhesion, and a larger surface, facilitates the immediate action,

same law which keeps all the planets, and the whole host of heaven in their respective places, and which must create in us more astonishment, that

---

and augments the energy, of chemical agents. It is for this purpose that bodies are divided when they are to be analysed, and that the effect of re-agents is facilitated by the action of heat.

The mechanical division of bodies is more difficult, the stronger their aggregation.

Aggregates exist under different states; they are solid, liquid, or aëriform.

OF THE AFFINITY OF COMPOSITION.

Bodies of different kinds exert a tendency or attraction upon each other, which is more or less strong; and it is by virtue of this force that all the changes of composition or decomposition observed amongst them, are effected.

The affinity of composition exhibits invariable laws in all the phenomena it causes. We may state these laws as general principles; to which may be referred all the effects presented to our observation by the action of bodies upon each other.

Law I. *The affinity of composition acts only between the constituent parts of bodies.*

The general law of attraction is exerted upon the masses; and in this respect it differs from the law of affinities, which does not perceptibly act but on the elementary particles of bodies. Two bodies placed near each other do not unite; but, if they be divided and mixed, a combination may arise. We have examples of this when the muriate of soda, or common salt, is triturated with litharge; the muriate of ammoniac, or common sal ammoniac, with lime, &c. And it may be asserted, that the energy of the affinity of composition is almost always proportioned to the degree of the division of bodies.

Law II. *The affinity of composition is in the inverse ratio of the affinity of aggregation.*

It is so much the more difficult to decompose a body, as its constituent principles are united or retained by a greater force. Gases, and especially vapours, continually tend to combination, because their aggregation is weak: and nature, which is constantly renewing the productions of this universe, never combines solid with solid; but, reducing every thing into the form of gas, by this means breaks the impediments of aggregation; and these gases uniting together, form solids in their turn.

Hence, no doubt, it arises, that the affinity of composition is so much the more strong as bodies approach nearer to the elementary state; and we shall observe, on this subject, that this law of nature is founded in great wisdom: for if the force of affinity of composition did not increase in proportion as bodies were brought to this degree of simplicity; if bodies did not assume a decided tendency to unite and combine, in proportion as they approach to their primitive or elementary state; the mass of elements would continually increase by these successive and uninterrupted decompositions; and we should insensibly return again to that chaos or confusion of principles, which is supposed to have been the original state of the globe.

The necessity of this state of division, which is so proper to increase the force of affinity, has caused it to be admitted as an incontestable principle, that the difficulty of composition does not take place, unless one of the bodies be in the fluid state: "*corpora non agunt nisi sint fluida.*" But it seems to me that extreme division might be substituted instead of dissolution; for both these operations tend only to attenuate bodies, without altering their nature. It is by virtue of this division, which is equivalent to the dissolution, that the decomposition of muriate of soda is effected by trituration with minium, as well as the union of cold and dry alkali with antimony, and the disengagement of volatile alkali by the simple mixture of sal ammoniac with lime.

Law III. *The compound which results from the combination of two bodies, possesses properties totally different from those of its constituent principles.*

Some chemists have affirmed, that the properties of compounds were intermediate between those of their constituent parts. But this term "intermediate" has no meaning in the present case; for what intermediate qualities can exist between sour and sweet, or between water and fire?

If we attend ever so little to the phenomena which are exhibited to us by bodies in their compo-

if a continued interference of omnipotent power was constantly being ex-

sition, we shall perceive that their form, their taste, and their consistence, are changed in combination; and we cannot establish any rule to indicate, *á priori,* all the changes which may arise, and the nature and properties of the body which shall be formed.

Law IV. *Every individual substance has its peculiar affinities with the various substances presented to it.*

If all bodies had the same degree of affinity with each other, no change could take place amongst them; we should not be able to displace any principle by presenting one body to another. Nature has therefore wisely varied the affinities, and appointed to each body its relation with all those that can be presented to it.

It is in consequence of this difference in the affinities, that all chemical decompositions are effected: all the operations of nature and art are founded upon it. It is therefore of importance to be well acquainted with all the phenomena and circumstances which this law of decomposition can present to us.

The affinity of composition has received different names, according to its effects; it is divided into simple affinity, double affinity, the affinity of an intermedium, reciprocal affinity, &c.

1. Two principles united together, and separated by means of a third, afford an example of simple affinity; it consists in the displacing of one principle by the addition of a third. Bergman has given it the name of *Elective Attraction.*

The body which is disengaged, or displaced, is known by the name of the *Precipitate.* An alkali precipitates metals from their solutions; the sulphuric acid precipitates the muriatic, the nitric, &c.

The precipitate is not always formed by the disengaged substance. Sometimes the new compound itself is precipitated; as, for example, when I pour the sulphuric or vitriolic acid on a solution of muriate of lime. Sometimes the disengaged body and the new compound are precipitated together; as, for example, when the sulphate of magnesia or Epsom salt is dissolved in water, and precipitated by means of lime water.

2. It often happens that the compound of two principles cannot be destroyed either by a third or a fourth body separately applied; but if these two bodies be united, and placed in contact with the same compound, a decomposition or change of principles will then take place. This phenomenon constitutes *double affinity.* An example will render this proposition more clear and precise. The sulphate of pot-ash or vitriolated tartar is not completely decomposed by the nitric acid or by lime, when either of these principles are separately presented; but, if the nitric acid be combined with lime, this nitrate of lime will decompose the sulphate of pot-ash. In this last case the affinity of the sulphuric acid with the alkali is weakened by its affinity to the lime. This acid, therefore, is subject to two attractions; the one which retains it to the alkali, and the other which attracts it towards the lime: Mr. Kirwan has named the first the *Quiescent Affinity,* and the other the *Divellent Affinity.* The same may be said respecting the affinities of the alkali; it is retained to the sulphuric acid by a superior force, but is nevertheless attracted by the nitric acid. Let us suppose, now, that the sulphuric acid adheres to the alkali with a force as 8, and to the lime by a force expressed by the number 6; that the nitric acid adheres to the lime by a force as 4, and tends to unite with the alkali by a force as 7. It may then be perceived that the nitric acid and the lime, separately applied to the sulphate of pot-ash, would not produce any change: but if they be presented in a state of combination, then the sulphuric acid is attracted on the one hand by 6, and retained by 8; it has therefore an effective attraction to the alkali as 2. On the other hand, the nitric acid is attracted by a force as 7, and retained by a force as 4; it therefore retains a tendency to unite with the alkali, which is denoted by the number 3; and consequently it ought to displace the sulphuric acid, which is retained only by a force as 2.

3. There are cases in which two bodies, having no perceptible affinity to each other, obtain a disposition to unite by the intervention of a third; and this is called the affinity of an intermedium. An alkali is the intermedium of union between oil and water; hence the theory of lixiviums, of washing, &c. &c.

If the affinities of bodies were well known, we might foretel the results of all operations: but it

erted;* and as fevers, or even actual combustion †, have arisen with us from a certain peculiar state, or combination of the elements, which in moderation, create

---

is obvious how difficult it must be to acquire this extensive knowledge of nature; more especially since modern discoveries have exhibited to us an infinity of modifications in our processes, and have shewn that results may vary with such facility, that even the absence or presence of light will render them very different.

As long as chemistry was confined to the knowledge of a few substances, and was busied only in attending to a certain number of facts, it was possible to draw up tables of affinity, and to exhibit the result of our knowledge in one and the same table. But all the principles upon which these tables have been constructed, have received modifications; the number of principles has increased; and we find ourselves under the necessity of labouring upon new ground. A sketch of this great work may be seen in the Essay on Affinities of the celebrated Bergman, and in the article Affinity in the *Encyclopéde Methodique*.

LAW V. *When two or more bodies unite by the affinity of composition, their temperature changes.*

This phenomenon cannot be explained but by considering the fluid of heat as a constituent principle of bodies, unequally distributed among them; so that, when any change is produced in bodies, this fluid is displaced in its turn, which necessarily produces a change of temperature.

* GOD governs by *second causes,* says the great Newton, and it certainly argues in that BEING most power to endow matter with such properties as may serve the intentions of the CREATOR, without HIS being obliged every moment to be adjusting its component parts, and animating the wheels of that stupendous machine. Equally is Nature dependant upon his will:—for if HE ceased his energy, matter would instantly lose its power. A child keeps on beating his top, and it spins round. GOD but *wills,* and the great globe moves round its own axis, and describes its appointed circuit, until matter loses the power delegated to it by the same *will,* which first implanted it.

† At first, the food taken into the stomach retaining its peculiar qualities, *irritates* the inner coat of that organ, and occasions a contraction of its two orifices. The food, thus confined, then undergoes a constant agitation by means of the abdominal muscles, and of the diaphragm, and by the motion of the fibres of the stomach itself. By these movements every part of the food is exposed to the action of a fluid secreted in the stomach, called *the gastric juice,* which (as water dissolves sugar) gradually dissolves and attenuates the food (as presently will be proved), and prepares it for its passage into, and farther change in, the intestines.

Our aliment is therefore broken down in the stomach into its constituent principles, and these comminuted parts then enter and pass along the capillaries of the intestines, which are incapable of admitting any substance, unless in an highly attenuated or *aerial* form.

The anatomical lecturer at Pisa, in the year 1597, happening to hold a lighted candle near the subject he was dissecting, on a sudden the vapours that issued from the stomach and intestines were set on fire. In the same year Dr. Ruisch was dissecting a woman, and had no sooner opened the stomach, than there issued out a yellow greenish flame, supposed to have arisen from the vapours, which were kindled by a student's holding a lighted candle near him.

Dr. Vulpare, the anatomical professor at Bologna, affirms that any one may see, issuing from the stomach of an animal, a vapour that *burns like spirits of wine,* if the upper and lower orifices are bound fast with a tight thread. The stomach thus tied up, must be cut immediately under the upper ligature, the contents of the stomach being first pressed with both hands, so as to pass to one side. A candle being held about half an inch from the aperture, a flame will be observed immediately to issue from the stomach.

Bartholine relates the case of a person, who having drank much brandy for a wager, died, after an eruption of a flame of fire had issued from his mouth. *The inflammable woman of Coventry,* as described by Mr. Wilmer, appears also to have reduced herself by dram-drinking to such a state as to be capable of being set on fire, and burn like any very combustible matter; *so eager,* says the learned Dr. Beddoes, *were the principles of which she was composed to combine with oxygen.*

the proper vital flame, so is terrestrial heat, as are also volcanoes and earthquakes to be considered by the philosopher as arising from a like source.

In like manner the countess *Cornelia Bandi*, near Cesena in Romagna, in 1731, in the sixty-second year of her age, was found in the middle of her bedchamber reduced to ashes. These ashes were light, and left in the hand a greasy and sticking moisture. The floor was smeared with a gross unpleasant moisture, and the walls and furniture were covered with a moist soot.

An instance of the same kind occurred at Christ-Church in Hampshire, June 26, 1613; one John Hitchell, a carpenter of that parish, a great drunkard, having ended his day's work, came home and went to bed. His wife found him dead before morning at her side. He felt so extremely hot, that it was impossible to touch him. *He lay burning for three days*; nor was there any appearance of flame outwardly, but only a smoke or mist ascending from his carcase till it was consumed.

On the night of the 16th of March 1802, in one of the towns of the State of Massachusetts, the body of an elderly woman evaporated and disappeared from some internal and unknown cause, in the duration of about one hour and an half. Part of the family had gone to bed, and the rest were abroad. The old woman remained awake to take care of the house. By and by one of the grand-children came home, and discovered something near the hearth to be on fire. An alarm was made, a light brought, and means taken to extinguish it. While these things were doing, some singular appearances were observed on the hearth and the contiguous floor. There was a sort of greasy soot and ashes, with remains of a human body, and an unusual smell in the room. All the clothes were consumed; and the grandmother was missing. It was at first supposed she had, in attempting to light her pipe of tobacco, fallen into the fire, and been burned to death. But on considering how small the fire was, and that so total a consumption could scarcely have happened if there had been ten times as much, there is more reason to conclude that this is another case of that spontaneous decomposition of the human body, of which there are several instances on record.

These curious instances of *quick combustion* carried on in the body, if I may be allowed to continue the expression, are adduced only as exceptions to Dr. Thornton's general rule, which he was the first to establish, " that within the body there is *always* carried on a *gentle combustion*, productive of *the vital flame*." Extracted from the Philosophy of Medicine, vol. ii. p. 21.

Fevers in like manner arise from a new combination of elementary matter, liberating heat, and thus destroying life. In this way several poisons produce their almost instantaneous effects, and hence to render meat tender, animals in the West Indies are killed by stabbing them with a needle infected with poison. A sufficient putrefaction, or tendering the meat, is thus instantaneously incurred, and the poison by entering into a new combination wholly loses its life-destroying power, and is therefore rendered innoxious. Vide the Philosophy of Medicine, Vol. IV. from page 117 to page 152.

To vindicate God as to the introduction of *evil* into *this nether world*, various have been the attempts of prying philosophers. That *evils* were *designed* to exist here is *undoubted*, although some make them only *accidental*. Considering this earth as a temporary abode for transient beings, whose life compared with eternity is as a grain of sand to the whole mass of this globe, or all the myriads of globes revolving round their respective suns, *nothing can be said to be an evil*, and as each respective world is probably only *a scene* of the *drama of the universe* for the *contemplation* of *us*, and of *other superior beings*; and as *our's* exhibits both the contrasts of *tragedy* and of *comedy* blended together, let us not, however, even utter a faint murmur at our *seven ages*, considering this only as a preparation in a *subordinary*, towards a *higher part*, which we shall have to act *next* as *angels*, or as *demons*, in a *higher* or *lower* world, *comfortable* or *inhospitable*, as *best appointed* for created beings progressive by their free-will in *virtues* or in *vices*, and so rightly stationed on *solid* or *unsound earth*, that is, either for *reward* or *punishment*, or, using the true interpretation of the scripture phrase, chastisement or correction.

SECT. XIX.

XII. ON ELECTRICITY AS PROMOTING GERMINATION.

Nymphs! your fine hands ethereal floods amass
From the warm cushion, and the whirling glass;
Beard the bright cylinder with golden wire,
And circumfuse the gravitating fire.
Bright from each point cerulean lustres gleam,
Or, shoot in air the scintillating stream.

Darwin.

Having amply considered the source and influence of heat on the seed, we are next led to contemplate the power of the *electric fluid* in promoting the progress of germination.

It must appear surprising to every searcher after truth, that electricity, which is now allowed to be one of the principal agents employed in producing the phænomena of nature, should have remained so long in obscurity; for, comparatively speaking, its existence was not known to the ancients. They were not, indeed, altogether ignorant of the peculiar properties of those bodies that we now term *electrics*;* nevertheless their knowledge was circumscribed, being confined to the observation only of those phænomena which nature presented to their senses, in the ordinary course of her operations; hence near two thousand years elapsed, before any addition was made to the little which was known to Theophrastus, and this branch of natural history remained uncultivated, till the happy period arrived, when the philosopher was emancipated from the chains of hypothetic reasoning, and the uncertainties of vague conjecture.

The existence of this subtle, and in most cases invisible power, was then traced, and many of its properties developed; its agency was discovered to be universal, and its extent unlimited.

* Thus the ancients knew the electric power of amber, and of sulphur, upon friction, and hence the derivation of the term of this science from ελεκτρον, which signifies amber in Greek.

It must be evident indeed, even to a superficial observer, that electricity is no trivial or confined subject; because there is no body in nature that is not acted upon in a greater or less degree by this wonderful agent.

The importance of the electric fluid in the system of the world, is confirmed by a consideration of those phænomena in which it is concerned, and which take place without the concurrent operation of man.

Thus several fishes possess the property of giving the electric shock. The torpedo, and one or more species of eels, from Surinam, if touched by the hand, a metal rod, or any other conductor, give a considerable shock to the arm, but may be safely touched by a bit of sealing-wax. The shock depends on the will of the fish, and is transmitted to a great distance; so that if persons in a ship happen to dip their fingers or feet in the sea, where the fish is swimming at the distance of fifteen feet, they will be affected therewith.

Otto Guericke, burgomaster of Madgeburgh, first made a globe of *sulphur*, and by whirling it about in a wooden frame, and rubbing it at the same time with his hand, he performed various electrical experiments. He added to the stock of knowledge the discovery, that a body once attracted by an excited electric was repelled by it, and not attracted again till it had touched some other body. Thus he was able to keep a feather suspended in the air over his globe of sulphur; but he observed, if he drove it near a linen thread, or the flame of a candle, it instantly recovered its propensity (if I may use the expression) for approaching the globe again. "The hissing noise," and the "gleam of light which his globe afforded, both attracted his notice."

These circumstances were, however, afterwards more accurately remarked by Dr. Wall, who, by rubbing *amber* upon a woollen substance in the dark, found also that light was produced in considerable quantities, accompanied with a crackling noise; and what "is still more extraordinary," he adds, "this light and crackling seems, in some degree, to represent thunder and lightning."

That the electric fluid and lightning were the same was, however, first *demonstrated* by the great Dr. Franklin. He early observed the power that points possess in drawing off the electricity of bodies, and thence inferred that a pointed metallic bar, if insulated at a considerable height in the air, would become electrical by communication from the clouds during a thunder-storm.

The first apparatus that exhibited this ethereal body was that of Mons. Dalibard, at Morly-la-ville, about six leagues from Paris.

It consists of a bar of the length of forty feet, and was electrified on the 10th of May 1752, for the space of an hour, during which time it emitted sparks, of two inches in length, which crackled like sparks issuing from an electrified conductor.

Dr. Franklin, about a month after this, devised a more certain method of ascertaining this curious hypothesis.

Instead of a rod, it occurred to him that he could have a readier and better access to the regions of thunder by means of a common kite.

He accordingly adjusted a silk handkerchief to two sticks placed crosswise. At the approach of the first storm he repaired to a field where there was an out-house conveniently situated for his experiment; and in order to obviate the ridicule that but too commonly accompanies unsuccessful attempts for the promotion of the sciences, he took care to communicate his intentions to no one but his son, whose assistance was absolutely necessary upon this occasion.

Having launched his kite into the air, with a pointed wire fixed to the end of it, he soon succeeded so far as to elevate it to the proper height. It was a long time before he discovered the least appearances of electricity. A dense black cloud had already passed over his head without any effect whatever, and he began actually to despair of success, when happening to look with more than ordinary attention, he at length perceived a lambent flame to stream along the hempen cord. The lightning (for it was actually such!) descended along the string, and was received by an iron key tied to the extremity of it, while this was connected with his hand by means of a piece of silken cord.

What must have been his joy, when presenting his knuckles to the key at the end of the hempen string, he felt an electric shock, and found out that his discovery was complete!

He now clearly perceived the electric sparks; more followed in succession, and when the string became humid by means of the rain, it conducted the electric fluid with still greater freedom, so that it would stream out plentifully from the key, at the approach of a person's finger. At this key he charged phials, and from electric fire thus obtained, kindled spirits, and performed all other electrical experiments which are usually exhibited by means of an excited globe or tube.

This memorable and indeed wonderful experiment took place in June 1752.

Mr. Baldwin raised an electrical kite in July, 1771, during the approach of a severe thunder storm, and observed himself to be surrounded by a rare medium of fire, which, as the cloud rose nearer the zenith, and the kite got higher, continued to extend itself with some gentle faint flashes. Mr. Baldwin felt no other effect than a general weakness in his joints and limbs, and a kind of listless feeling; all which, he observes, might possibly be the effect of surprise, though it was sufficient to discourage him from persisting in any farther attempt at that time. He therefore drew in the kite, and retired to a shop till the storm was over, and then went to his house, where he found his parents and friends much more surprised than he had been himself; who, after expressing their astonishment, informed him, that he appeared to them (during the time he was raising the kite) to be in the midst of a large bright flame of fire, attended with flashings; and that they expected every moment to see him fall a sacrifice to the flame.*

Having succeeded so completely with his electrical kite, Dr. Franklin determined to persevere in his observations. He accordingly erected an insulated iron rod,† on purpose to draw the lightning into his house, to make experiments whenever there should be a considerable quantity of it in the atmosphere; and, that he might not lose any opportunity of that nature, he

---

* Professor Richman of Petersburgh, afterwards as he was pursuing these experiments (so happily begun by Dr. Franklin) was struck dead in the midst of his family.

> NYMPHS! on that day ye shed from lucid eyes
> Celestial tears, and breathed ethereal sighs!
> When RICHMAN rear'd, by fearless haste betray'd,
> The wiry rod in Nieva's fatal shade;—
> Clouds o'er the sage, with fringed skirts succeed,
> Flash follows flash, the warning corks recede,
> Near and more near he ey'd with fond amaze
> The silver stream, and watch'd the sapphire blaze;
> Then bursts the steel, the dart electric sped,
> And the bold sage lay number'd with the dead!
>
> DARWIN.

† This discovery, although it seemed to the ignorant and superficial to be only a matter of curiosity and surprise, was attended with consequences highly beneficial to the human race. The grand practical use which our author converted it to, was, to prevent buildings from being damaged by lightning. This he accomplished by fixing a metallic rod higher than any part of the edifice, and contriving it in such a manner as to communicate with the earth, or rather with the nearest water. The lightning was sure to seize upon the rod, preferably to any other part of the building, and that dangerous element, instead of committing its usual destruction, was harmlessly brought in contact with the ground, without doing any mischief whatever.

connected two bells with his apparatus, which gave him notice by ringing, whenever his rod was electrified.

Jupiter, the supreme god of the ancients, being thus disarmed of his terrors, the subject was taken up with the utmost philosophical ardour.

Thunder storms, says Beccaria, generally happen when there is little or no wind, and their first appearance is marked by one dense cloud, or more, increasing very fast in size, and rising into the higher regions of the air; the lower surface black, and nearly level, but the upper finely arched, and well defined. Many of these clouds seem frequently piled one upon another, all arched in the same manner; and they keep continually uniting, swelling, and extending the arches.

At the time of the rising of this cloud, the atmosphere is generally full of a great number of separate clouds, motionless, and of odd and whimsical shapes. All these, upon the appearance of the thunder cloud, draw towards it, and become more uniform in their shapes as they approach, till coming very near the thunder cloud, their limbs mutually stretch towards one another; they immediately coalesce, and together make one uniform mass.

When the thunder cloud is grown to a great size, its lower surface is often ragged, particular parts being detached towards the earth, but still connected with the rest. Sometimes the lower surface swells into various large protuberances, bending uniformly towards the earth. When the eye is under the thunder cloud, after it is grown larger, and well formed, it is seen to sink lower, and to darken prodigiously, at the same time that a number of small detached clouds (the source of which can never be perceived) are seen in a rapid motion, driving about in a very uncertain direction under it.

A cloud in a thunder storm may be considered as a great conductor, actually insulated and electrified;* and it may be supposed to have the same effect upon those non-electrics which it meets with in its course, as our common conductors have upon those which are presented to them. If a cloud of this kind meets with another which is not electrified, or less so than itself, the electric matter flies off from all parts towards this cloud; hence proceed flashes of lightning, and the formidable report of thunder.

---

* Professor Saussure, when passing the Alps, meeting with thunder-clouds, found his body immediately replete with the electric fluid, and having insulated himself by means of a stool with glass feet, his companion Mons. Galabert observed his hair to stand an end, and sparks were drawn from him with a crackling noise, as in those electrified by art. This is another corroboration of the truth of Dr. Franklin's great discovery.

The zig-zag kind of lightning is extremely dangerous, because it must overcome a very violent resistance of the atmosphere, and wherever that resistance is in the smallest degree lessened, there it will undoubtedly strike, and even at a considerable distance. It is otherwise with that kind which appears in flashes of no determinate form; the electric matter of which is evidently dissipated in the air by some conducting substances which are present there, and they are therefore rendered less powerful.

The most destructive kind of lightning is that which assumes the form of balls. These are produced by an exceeding great power of electricity, gradually accumulated till the resistance of the atmosphere is no longer able to confine it. In general, the lightning breaks out from the electrified cloud by means of the approach of some conducting substance; but the fire-balls seem to be formed not because there is any substance at hand to attract the electric matter from the cloud, but because the electricity is accumulated in such a quantity that the cloud can no longer contain it. Hence, such balls fly off slowly, and have no particular destination; their appearance indicates a prodigious commotion and accumulation of electricity in the atmosphere, without a proportionable disposition in the earth to receive it.

From a number of observations, the indefatigable Beccaria also endeavours to account for the rising of vapours and the fall of rain, upon electrical principles; and, it must be confessed, that if it is not a primary agent in these effects, it would be rashness entirely to deny its influence. This philosopher supposes, that previous to rain a quantity of electric matter escapes from the earth, and in its ascent to the higher regions of the air collects and conducts into its path a great quantity of vapours. The same cause that collects will condense them more and more, till in the places of the nearest intervals they come almost in contact, so as to form small drops, which, uniting with others as they fall, come down in rain. The rain he supposes to fall heavier in proportion as the electricity is more vigorous.

Hail, he supposes to be formed in the higher regions of air, where the cold is intense, and where the electric matter is very copious. In these circumstances, a great number of particles of water are brought near together, where they are frozen, and in their descent collect other particles; so that the density of the substance of the hail-stone grows less and less from the center, this being formed first in the higher regions, and the surface being collected in the lower. Agreeably to this, it is observed, that on mountains,

hail-stones and drops of rain are very small,* there being but a small space through which they can fall.

Clouds of snow differ in nothing from clouds of rain, but in the circumstance of the cold which freezes them.†

Low and thick fogs (especially when as they rise the air above them is free from moisture) carry up to the exploring wire an electricity which will give small sparks repeatedly, and produce a divergence of the balls ‡ from

---

* Clouds consist of very small globules, which are repelled from each other by the power of electricity, and when these, from a deficiency of this fluid, assemble together by the natural adhesive attraction possessed by homogeneous bodies, it is then that the *shower* descends, as these are no longer buoyant, and still losing the elastic influence from the earth being in a negative state with respect to the air, the drops increase and assume a decided form. This is beautifully illustrated by hanging a small metallic vessel containing water on the conductor of an electrical apparatus, with a capillary syphon affixed to it. The water from the syphon falls in drops: but *when electrified*, these divide into numberless smaller ones, so as to resemble what is called a Scotch mist, i. e. the rain on the tops of mountains, or those November mists when the equilibrium of the electric fluid is on the earth, and in the heavens nearly equipoised.

† This phænomenon is often seen in crowded assembly-rooms at Petersburgh. When the cold air is let in from the top of the room by a contrivance on purpose for ameliorating the air, the floating vapour will be suddenly frozen, and attach together, and fall down in the form of thin flakes of snow. That snow is composed of a congeries of small spicula, is proved from the following pleasing experiment. Take a tall phial of the nitrous acid, warm it, add to it the filings of silver by degrees, which will dissolve. The phial being placed in a cold window, as it cools, the silver particles will shoot into crystals; several of these uniting will form a flake, and these precipitating from their increased weight, will fall to the bottom of the phial, as silver flakes, and one flake lie upon another, like those of snow. The lightness of snow, although in fact solid ice, is merely owing to the extent of surface, as the silver in the above experiment, or as gold can be so extended in surface, as to ride upon the least breath of air. Its whiteness is owing to the smallness and disjunction of the spicula forming its composition, for ice when pounded will appear equally white. For further particulars respecting snow, vide Section xiii, page 70.

‡ Balls of pith insulated and suspended shew the quantity, or power of the electric fluid. Thus if suspended in a fog or mist they separate with positive electricity.

The terms *positive* and *negative*, as applied to electricity, are thus explained by Dr. Franklin. "Positive electricity is when there is an accumulation of the electric fluid, or too great a quantity in any body, and negative when there is a deficiency."

When the remarkable phænomenon of the charged phial was discovered by Muschenbroek at Leyden, no plausible theory was advanced for its explanation previous to Dr. Franklin. From some experiments he was induced to suppose that electricity was a single elementary fluid, which he termed electrical fire; and that its phænomena depended upon the different proportions in which it is formed; that this fire was equally diffused throughout all bodies, and when, upon any disturbance, there was more than the natural quantity accumulated, this excess he expressed by the term positive; and when there was any deficiency, such was implied by the term negative. This philosopher supposes twenty particles of electricity on the inside, and the same quantity on the outside; so that when the quantity withinside was doubled, the whole of the outside was expelled. Glass, according to Dr. Franklin, is not permeable to electricity. These two electricities have been since denominated the *vitreous* and *resinous*. In the year 1733, Mons. Du Faye, intendant of the French King's gardens, and member of the Academy of Sciences at Paris, discovered, as he thought, two opposite and distinct species of electricity, which he termed the vitreous and resinous. "Chance," says this philosopher, has "thrown in my way an universal principle, which casts a new light upon the subject of electricity.

20°to 25°, or even 30°. If the fog grows sluggish, and continues round the exploring wire, the electricity soon fails; but if it continues to rise, and ano-

---

The principle is, that there are two distinct kinds of electricity, very different from one another; one of which I call vitreous, and the other resinous electricity. The first is that of glass, rock crystal, precious stones, hair of animals, wool, and many other bodies. "The second is that of amber, copal, gum lac, silk, thread, paper, and a vast number of other substances."

"The characteristic of the two electricities is, that they repel themselves, and attract each other. Thus a body of the vitreous electricity repels all other bodies possessed of the vitreous; and, on the contrary, attracts all those of the resinous electricity. The resinous also, repels the resinous, and attracts the vitreous. From this principle, one may easily deduce the explanation of a great number of phænomena; and it is probable, that this truth will lead us to the discovery of many more things."

The difficulties attending the Franklinian System, respecting the impermeability of glass, induced Messrs. Eeles, Symner, Atwood, and others, to adopt the idea of Du Faye, of there being two distinct kinds of electricities; with this difference, Du Faye supposed the electricities existed naturally different in different bodies, while these gentlemen suppose, that the two electricities are always united, and only evince their power when separated; that when in union they counteract each other, so as in this state are perfectly tranquil. When they are divided, they each have uncontrolled their separate power; and their strong attractive nisus to unite, is the cause of every electrical appearance.

By thus regarding electricity as a compound of two distinct principles, which, when divided, will permeate glass, they thus attempt to explain the *Leyden Phial.*

These two principles they term, after Du Faye, the vitreous and resinous electricity; and farther assume, that similar electricities repel each other, and contrary electricities attract.

By the action of the rubber on the cylinder, the electricities of the rubber are decomposed; that the vitreous portion is separated and given to the cylinder, and takes back as much resinous electricity; the cylinder gives out the vitreous portion it has just received to the conductor, and receives back an adequate portion of resinous electricity; the conductor imparts this vitreous portion to the inside of the Leyden jar, and takes back its resinous portion; this additional vitreous portion repels the vitreous portion from the outside, while the resinous portion on the outside is attracted within. At this period there is no electricity on the outside, but what is uncombined; hence, with rapidity, will attract the opposite electricity, when it meets with no resistance.

In general clouds shew the positive electricity, but in thunder storms there is a quick transition from positive, or vitreous, to negative, or resinous, and this continues until the battling clouds appear to lose their resinous electricity, and the positive, or vitreous state is established. Such is the explanation of the thunder-storm by those who espouse the doctrine of two contrary electrics. Thus if we consider the clouds as one of the coating of the Leyden phial, the lower dense air, as the glass, or electric, and the earth as the other coating, we may contemplate the Leyden bottle upon a grand scale, producing thunder, lightning, earthquakes, and the aurora-borealis. Fig. 33, *a*, is a portion of the earth's surface; *c* the lower non-conducting part of the atmosphere; *d* the clouds; *g* the positive electricity of the clouds, met by the negative, *q*, of the earth; *n* the explosion; *z z* the electric stream from the sun. When the air is very dry, and much saturated with electricity, it resists the entrance of more; and hence the reason why thunder generally follows such weather, and is more prevalent in summer than winter. When the air is moist, electricity finds an easy passage into the earth, without commotion; and hence the earth has been generally considered as the grand reservoir of it; and from that reservoir we pump it by electric machines and other frictions, being incapable by such means of exciting much from the air. When the rays of electricity, therefore, come the most directly on the earth, as in summer, a greater quantity may be poured on the dry air than it can conduct, and hence the clouds will be in a positive or abundant state, while the earth, comparatively, may be in a negative state; the consequence will be a violent effort to restore equality by a storm of thunder and lightning; and the air near the earth will be found positive and negative by fits, while the storm lasts. When the clouds are scattered at a distance from one another, the lightning is often seen darting from one to another, where the air is

ther cloud succeeds, it electrifies again the wire, though less than before. Sky-rockets sent through such thick, low, and continued fogs, often afford signs of electricity.

Dr. Franklin's theory is as follows. The electric fluid, says this ingenious philosopher, is strongly attracted by water; and by destroying the cohesion between its particles, and repelling them from each other, it becomes a powerful agent in evaporation.* The waters of the ocean abound in this

---

too rare or thin to form much resistance to its passage, and then we see lightning without hearing thunder. An humble imitation of those effects may be produced by the two circular boards, Fig. 26, about two feet in diameter, their edges rounded, and the whole covered with tin-foil. Let one be suspended from the ceiling by clean silken cords; and the other sustained on glass feet, parallel to the other; but so as to be brought nearer or farther from another. If the upper board be connected with the conductor, and the lower with the earth, and separated about two inches distant, and electrified; one hand touching the lower, and the other the upper, a shock will be received as far from the Leyden bottle; for, as has been shewn, it is but a plate of air that is charged instead of a plate of glass; the upper board being in a positive, and the under in a negative, state: the shock being in proportion to the quantity of electricity, and the ease with which it can escape from the positive side of the electric. The two plates strongly attract each other, and would come together, if not kept asunder by force: sparks flying between them will frequently destroy the electricity of each. If the under surface of the upper plate be covered with gilt leather, and a smooth shilling be laid on the lower plate, beautiful ramifications will fly about the leather, and dart to the shilling, when electrified. In this experiment the upper plate naturally represents a positive cloud, and the under one the earth, with the manner in which lightning darts from the clouds to the earth; and if a Leyden phial be connected with the conductor, the flash and report will be still the greater. Vide WALKER'S PHILOSOPHY.

* Those who have not been accustomed to contemplate the occurrences of natural events will be astonished to be informed, that an acre of ground, even after having been parched by the heat of the sun in summer, disperses into the air above one thousand six hundred gallons of water, in the space of twelve hours. The experiment from which this conclusion is drawn is as follows. On the 2d of June, 1779, when the sun shone bright and hot, I put, says the learned bishop of Landaff, a large drinking glass, with its mouth downwards, upon a grass-plat which was mown close; there had been no rain, for above a month, and the grass was become brown; in less than two minutes the inside of the glass was clouded with a vapour, and in half an hour drops of water began to trickle down its inside, in various places. This experiment was repeated several times with the same success. That I might accurately estimate the quantity, thus raised, in any certain portion of time, I measured the area of the mouth of the glass, and found it to be 20 square inches: there are 1296 square inches in a square yard, and 4840 square yards in a statute acre; hence, if we can find the means of measuring the quantity of vapour raised from 20 square inches of earth, suppose in one quarter of an hour, it will be an easy matter to calculate the quantity which would be raised with the same degree of heat, from an acre in 12 hours. The method I took to measure the quantity of vapour, was not perhaps the most accurate which might be thought of, but it was simple and easy to be practised: when the glass had stood on the grass-plat one quarter of an hour, and had collected a quantity of vapour, I wiped its inside with a piece of muslin, the weight of which had been previously taken; as soon as the glass was wiped dry, the muslin was weighed again, its increase of weight shewed the quantity of vapour which had been collected. The medium increase of weight, from several experiments made on the same day, between 12 and 3 o'clock, was six grains collected in one quarter of an hour, from 20 square inches of earth. If the reader takes the trouble to make the calculation, he will find that above 1600 gallons, reckoning 8 pints to a gallon, and estimating the weight of a pint of water at one pound avoirdupois, or 7000 grains troy weight, would be raised, at the rate here mentioned, from an acre of ground in 24 hours.

It may easily be conceived, that the quantity thus elevated will be greater when the ground has

electric fire, and vapours raised from them float in the air, forming clouds, which retain their electricity till they meet with other bodies, either destitute of it,

---

been well soaked with rain, provided the heat be the same. I did not happen to mark the heat of the ground when I made the fore-mentioned experiments; the two following are more circumstantial: the ground had been wetted the day before I made them by a thunder shower, the heat of the earth, at the time of making them, estimated by a thermometer laid on the grass, was 96 degrees; one experiment gave 1973 gallons from an acre in 12 hours, the other gave 1905. Another experiment, made when there had been no rain for a week, and the heat of the earth was 110 degrees, gave after the rate of 2800 gallons from an acre in 12 hours; the earth was hotter than the air, as it was exposed to the reflexion of the sun's rays from a brick wall.

To shew how much *electricity* has to do with this phænomenon, the learned bishop made afterwards the following experiments. Upon the same grass-plat, and contiguous to the glass used in these experiments, I placed a silver cup, with its mouth downwards, of a shape similar to that of the glass, and nearly of the same dimensions; but I could never observe that its inside had collected the least particle of vapour, though I frequently let it stand on the grass for half an hour, or more.

By means of a little bees-wax, I fastened an half crown very near, but not quite contiguous, to the side of the glass, and setting the glass, with its mouth downwards, on the grass, it presently became covered with vapour, except that part of it which was near to the half-crown. Not only the half-crown itself was free from vapour, but it had hindered any from settling on the glass which was near it, for there was a little ring of glass surrounding the half-crown to the distance of three quarters of an inch which was quite dry, as well as that part of the glass which was immediately under the half-crown; it seemed as if the silver had repelled the water to that distance. A large red wafer as containing lead had the same effect as the half-crown; it was neither wetted itself, nor was the ring of glass contiguous to it wetted. A circle of white paper produced the same effect, so did several other substances, which it would be tedious to enumerate.

These phænomena respecting the different dispositions of different bodies to attract the *rising* vapour, are similar to what others have noticed concerning the *falling* of dew, and are, probably, to be explained upon the same principles, whatever they may be. Muschenbroek placed on the leaden terrace of the Observatory at Utretcht, vessels of glass, china, varnished wood, polished brass, and pewter: he found that in the course of a night the glass, china, and varnished wood, had collected a great abundance of dew, but that not a drop had fallen on any of the polished metals. M. Du Faye exposed to the air, when the dew was falling, two large funnels, one made of glass, the other of polished pewter; the necks of the funnels being inserted into vessels proper to retain any moisture which might be collected by them; he sometimes found in the morning that the vessel under the glass funnel contained an ounce of more water, but he never observed so much as a drop in the other. These experiments are found to correspond with those of the Abbé Nollet, who found, that evaporation of all fluids was accelerated by electricity, hence their quick and sudden ascension in capillary vessels, from this power, and hence their quicker diffusion in the air, when contained in metallic vessels than in those fabricated of glass.

Thus it is that *evaporation* is the product of both heat and electricity, and water rises in the air, flying on the wings of electricity, till it arrives at those cold and rare regions, which is a conductor of electricity (for air approaching to a vacuum is found to be a conductor). To this thin, or rare air, electricity has a greater affinity than to water, the water becomes in part forsaken, and its particles attracting each other, lose their transparency, and clouds are generated, which drop, according to the respective densities of the stratas of air. If still more electricity be withdrawn then *rain* is produced: or that *haziness* which is sometimes seen to proceed on a sudden, overcasting, what appeared but a few minutes before, the brightness of an universal azure, which can be accounted for upon no other principle. That evaporation, clouds and rain are thus produced, may be elegantly illustrated by hanging a pair of small pith balls, by flaxen threads, in a receiver, and electrifying them positively: if the receiver be placed on the air-pump, and exhausted, the balls will close; but when the vapour becomes forsaken, and descends in the receiver, the balls open with negative electricity, shewing that the rarefied air absorbed the electricity, and left the water to which it was united; thus completely forsaken, it falls within the receiver, an actual shower of rain.

or containing it in a less proportion than themselves. This, in all probability, is frequently the case with those vapours or clouds which are produced by exhalations from the earth, from fresh water, and the perspiration of plants and trees; at least it is an undoubted fact, that some clouds (to use the language of this branch of philosophy) are electrified *positively*, and others *negatively*. No sooner does a communication take place, but the repulsion between the particles of water is diminished, those which have discharged part of their electricity are successively attracted by the contiguous ones which have not, and thus they press nearer together, become specifically heavier than the atmosphere, and descend in small drops, which, losing every instant more and more of the electric fire, coalesce, uniting into larger and larger drops, and consequently filling a space which is continually diminishing, as they approach nearer to the surface of the earth. This may be illustrated by electrifying the stream of a fountain, which will spread itself into the form of a brush by the mutual recession of the particles of water: but withdraw the supply of electric fire, and the fountain discharges itself in one continued current.* A pair of cork balls suspended together by silken threads, when electrified recede from each other, and if the air be dry, return by degrees only to their natural position. Two feathers electrified will float in the atmosphere, mutually repelling each other, when in a certain degree of contiguity, and gradually descending as they lose that power, which by expanding their *plumulæ*, rendered them specifically lighter than the air. But if one of them discharges suddenly the electric fire, it will instantly be attracted towards the other, and receive a fresh supply; when a repulsion (acting indeed at a much less distance than before) will again take place between them.

When two clouds, one replete with electric fire, the other destitute of it, come within the sphere of each other's attraction, they will rush together, and the electrical fluid being diffused through a larger space, the particles of water will unite, and form themselves into drops of greater magnitude, and a heavy shower will be produced. Still however as the rain descends through an atmosphere containing little electric fire, it will be continually communicating it, and the discharge being greatest from the circumference of the cloud, because the surface is there largest, the drops will be drawn

---

* Vide Note page 157.

nearer and nearer to each other, and, approaching towards one common centre, will gradually coalesce in their passage.

Doctor Franklin has related a most ingenious experiment, which elucidates the formation of rain as thus described.

Take round pieces of pasteboard of two inches diameter; from the centre and circumference of each of them suspend, by fine silk threads eighteen inches long, seven small balls of wood, or seven peas equal in bigness; so will the balls appending to each pasteboard form equal equilateral triangles, one ball being in the centre, and six at equal distances from that and each other; and thus they represent particles of air. Dip both sets in water, and, some adhering to each ball, they will represent air loaded. Dexterously electrify one set, and its balls will repel each other to a greater distance, enlarging the triangles. Could the water supported by the seven balls come into contact, it would form a drop or drops so heavy as to break the cohesion it had with the balls, and so fall.

Let the two sets then represent two clouds, the one a sea cloud electrified, the other a land cloud; bring them within the sphere of attraction, and they will draw towards each other, and you will see the separated balls close thus:— The first electrified ball that comes near an unelectrified ball, by attraction, joins it and gives it fire; instantly they separate, and each flies to another ball of its own party, one to give, the other to receive fire; and so it proceeds through both sets, but so quick as to be, in a manner, instantaneous. In their collision they shake off and drop their water, which will represent rain.

But it rarely happens, that a land cloud is equal in magnitude to one raised from the sea; consequently the rain produced by their union, will be proportionably lighter in the upper, and heavier in the lower regions of the atmosphere, as the electric matter is more or less gradually diffused.

When an electrified cloud, without mixing with another cloud, or losing part of its electric fire, becomes specifically heavier than the atmosphere, by cold, or some local change in the density of the air, it will descend at first perhaps in a mist; or will form, as it approaches nearer to the earth, and is less replete with the electric fluid, a light shower of rain.

In confirmation of this doctrine is the discovery of the late Dr. Heberden, which was read before the Royal Society, Dec. 7, 1769. This amiable and sagacious physician writes as follows:

A comparison having been made between the quantity of rain which fell in two places in London, about a mile distant from one another, it was found that the rain in one of them constantly exceeded that in the other, not only every month, but almost every time that it rained.

The apparatus used in each of them was very exact, both being made by the same artist; and upon examining every probable cause, this unexpected variation did not appear to be owing to any mistake, but to the constant effect of some circumstance, which not being supposed to be of any moment, had never been attended to. The rain-gauge in one of these places was fixed so high as to rise above all the neighbouring chimnies; the other was considerably below them; and there appeared reason to believe, that the difference of the quantity of rain in these two places was owing to this difference in the placing of the vessel in which it was received. A funnel was therefore placed above the highest chimnies, and another upon the ground of the garden belonging to the same house, and there were found the same difference between these two, which there had been between them, when placed at similar heights in different parts of the town. After this fact was sufficiently ascertained, it was thought proper to try, whether the difference would be greater at a much greater height; and a rain-gauge was therefore placed upon the square parts of the roof of Westminster Abbey, being at such a distance from the western towers as probably to be very little affected by them, and being much higher than any other neighbouring buildings.

Here the quantity of rain was observed for a twelvemonth, the rain being measured at the end of every month, and care being taken, that none should evaporate, by passing a very long tube of the funnel into a bottle through a cork, to which it was exactly fitted. The tube went down very near to the bottom of the bottle, and therefore the rain, which fell into it, would soon rise above the end of the tube, so that the water was no where open to the air except for the small space of the area of the tube: and by trial it was found, that there was no sensible evaporation through the tube thus fitted up.

The following table will shew the result of these observations.

From July the 7th, 1766, to July the 7th, 1767, there fell into a rain-guage fixed

	Below the top of a house.	Upon the top of a house.	Upon Westminster Abbey.
	Inches.	Inches.	Inches.
1766, From the 7th of July to the end	3,591	3,210	2,311
August	0,558	0,479	0,508
September . . .	0,421	0,344	
October	2,364	2,661	1,416
November . . .	1,079	0,842	0,632
December . . .	1,612	1,258	0,994
January	2,071	1,455	1,035
February	2,864	2,494	1,335
March	1,807	1,303	0,587
April	1,437	1,213	0,994
May	2,432	1,745	1,142
June	1,977	1,426	1,145
From the 1st of July to the 7th . . .	0,395	0,309	
	22,608	18,139	12,099

By this table it appears, that there fell below the top of a house above a fifth part more rain than what fell in the same space above the top of the same house, and that there fell upon Westminster Abbey not much above one half of what was found to fall in the same space below the top of the houses. What may be the cause of this extraordinary difference, adds Dr. Heberden, has not yet been discovered; but it may be useful to give notice of it, in order to prevent that error, which would frequently be committed in comparing the rain of two places without attending to this circumstance.

It is probable, that some hitherto unknown property of *electricity* is concerned in this phænomenon. This power has undoubtedly a great share in the descent of rain, which hardly ever happens, if the air and electrical apparatus be sufficiently dry, without manifest signs of electricity in the air. Hence it is, that in Lima, where there is no rain, they never have any lightning or thunder *; and that, as M. Tournefort was assured, it never rains in the Levant but in winter, and that this is the only season in which any thunder is heard†. If this appearance therefore could be accounted for, it would probably help us to some more satisfactory causes of the suspension of the clouds, and of the descent of rain.

* See the English translation of the Voyage of Don George Juan and Don Antonio de Ulloa, to South America, Vol. III. Book I. chap. 6. p. 69 and 79.

† Voyage du Levant, Let. x. p. 423.

The Aurora Borealis is too much connected with our subject, and so extraordinary a phænomenon, that we must beg farther to intrude upon the patience of our candid reader.

Franklin was also the first who has attempted a reasonable hypothesis respecting the aurora borealis. He reasons thus. Air heated by any means becomes rarefied, and specifically lighter than other air in the same situation not heated, and when lighter it rises, and the neighbouring cooler and heavier air takes its place. If in the middle of a room you heat the air by a stove, or pot of burning coals, near the floor, the heated air will rise to the ceiling, spread over the cooler air till it comes to the cold walls; there being condensed and made heavier, it descends, to supply the place of that cool air which had moved towards the stove or fire, in order to supply the place of the heated air which had descended. Thus there will be a continual circulation of air in the room, which may be rendered visible by making a little smoke, for that smoke will rise and circulate with the air.

A similar operation is performed by nature on the air of this globe. Above the height of our atmosphere the air is so rare as to be almost a vacuum. The air heated between the tropics is continually rising; its place is supplied by northerly and southerly winds, which come from the cooler regions. The light heated air floating above the cooler and denser, must spread northward and southward, and descend near the two poles, to supply the place of the cool air, which had moved towards the equator. Thus a circulation of air is kept up in our atmosphere, as in the room above mentioned. That heavier and lighter air may move in currents of different and even opposite direction, appears sometimes by the clouds that happen to be in those currents, as plainly as by the smoke in the experiment above mentioned; also, in opening a door between two chambers, one of which has been warmed; by holding a candle near the top, near the bottom, and near the middle, you will find a strong current of warm air passing out of the warmed room above, and another of cool air entering below, while in the middle there is little or no motion.

The great quantity of vapour rising between the tropics forms clouds, which contain much electricity;* some of them fall in rain, before they come

---

* The meteors of the torrid zone are different from those which are found near the polar circles; for there the sun exerting his greatest force, raises vapours of various kinds, which form a great variety

to the polar regions. Every drop brings down some electricity with it; the same is done by snow or hail, the electricity so descending, in temperate climates, is received and imbibed by the earth. If the clouds are not sufficiently discharged by the gradual operation, they sometimes discharge themselves suddenly by striking into the earth, where the earth is fit to receive their electricity. The earth in temperate and warm climates is generally fit to receive it, being a good conductor.

The humidity contained in all the equatorial clouds that reach the polar regions, must there be condensed, and fall in snow. The great cake of ice that eternally covers those regions may be too hard frozen to permit the electricity, descending with that snow, to enter the earth. It may therefore be accumulated upon that ice. The atmosphere being heavier in the polar regions than in the equatorial, will there be lower; as well from that cause, as from the smaller effect of the centrifugal force: consequently the distance of the vacuum above the atmosphere will be less at the poles than elsewhere, and probably much less than the distance (upon the surface of the globe) extending from the pole to those latitudes in which the earth is so thawed as to receive and imbibe electricity. May not then the great quantity of electricity brought into the polar regions by the clouds, which are condensed there, and fall in snow, which electricity would enter the earth, but cannot penetrate the ice; may it not, as a bottle overcharged, break through that low atmosphere, and run along into the vacuum over the air towards the

---

of meteors. Upon the approach of the winter months, as they are called, under the line, the sky, from a fiery brightness, begins to be overcast, and the whole horizon seems wrapped in a muddy cloud. Mists and vapours still continue to rise; and the air, which so lately before was clear and elastic, now became humid, obscure, and stifling: the fogs became so thick, that the light of the sun seems in a manner excluded; nor would its presence be known, but for the intense and suffocating heat of its beams, which dart through the gloom, and, instead of dissipating, only serve to increase the mist. After this preparation, there follows an almost continual succession of thunder, rain, and tempests. During this dreadful season, the streets of cities flow like rivers, and the whole country wears the appearance of an ocean. The inhabitants often make use of this opportunity to lay in a stock of fresh water for the rest of the year; as the same cause which pours down the deluge at one season, denies the kindly shower at another. The thunder which attends the fall of these rains, is much more terrible than what we are generally acquainted with. With us, the flash is seen at some distance, and the noise shortly after ensues; our thunder generally rolls on one quarter of the sky, and one stroke pursues another. But here it is otherwise; the whole sky seems illuminated with unremitted flashes of lightning; every part of the air seems productive of its own thunders; and every cloud produces its own shock. The strokes become so thick, that the inhabitants can scarce mark the intervals; but all is one unremitted roar of elementary confusion. Vide PAINE's GEOGRAPHICAL EXTRACTS, a very amusing and instructive work.

equator; diverging as the degrees of longitude enlarge; strongly visible where densest, and becoming less visible as it more diverges; till it finds a passage to the earth in more temperate climates, or is mingled with the upper air? If such an operation of nature were really performed, would it not give all the appearance of an *aurora borealis?* And would not the auroras become more frequent after the approach of winter; not only because more visible in longer nights, but also because in summer the long presence of the sun may soften the surface of the great ice-cake, and render it a conductor, by which the accumulation of electricity in the polar regions will be prevented?"

Nature has done most, where her efforts seem most wanted. In Sect. XIII. we showed the peculiarity of the Lapland year, and we cannot help now observing her kindness, when the sun no longer spreads his influence of light, by substituting the powers of the electric fluid.

> By dancing meteors then, that ceaseless shake
> A waving blaze refracted o'er the heavens,
> And vivid moons, and stars that keener play
> With double lustre from the glossy waste;
> Ev'n in the depth of *polar night* they find
> A *wondrous* day: enough to light the chase,
> Or guide their daring steps to Finland fairs.
>
> Thomson.

As soon as the Lapland winter ceases, besides the oxygenation of the earth from the melting snows, the accumulated electric fluid penetrates the ground, and aids the other powers in accelerating the growth of plants.

That the electric fluid has some sensible effect upon vegetation, even common observation has pointed out.

It has been universally noticed that grass grew stronger in patches where the earth had been struck with lightning, and that there mushrooms would spring up.

This increased fertility of soil were denoted *fairy rings* by vulgar superstition, who seeing the effect were wont to attribute it to a supernatural cause. I remember, says Dr. Darwin, some circles of many yards diameter of this kind near Foremark, in Derbyshire, which annually produce large white funguses, and stronger grass, and have done this, I am credibly informed, more than thirty years.

Experiments have been purposely made with the electric fluid to ascertain its influence on vegetation.

The famous Abbé Nollet, after having discovered the quicker rise of

water in capillary tubes from the addition of the electric fluid, and the faster flow of the blood in the animated body, instituted some experiments on plants.

EXPERIMENT FIRST.

He took garden-pots, and filled them with the same kind of earth, and sowed them with the same kind of seed.

He kept them constantly in the same place, and the same position as to light, and gave each the same quantity of water: but one was electrified daily from two to three, and sometimes four hours, a day.

The consequence was, the electrified pot shewed its germs by *three days sooner* than *the other*. It had longer shoots in a given time, and looked more vigorous withal.

The Abbé Berthollon next drew the attention of the learned world to this subject, and having opened the glorious career, many other philosophers followed the same path, among whom the L'Abbé D'Ormoy's Experiments seem the most conclusive.

SECOND AND THIRD EXPERIMENTS.

On the 21st of March, 1788, I electrified, says the Abbé D'Ormoy, during the space of twelve hours, a *magic board,* recharging it successively, when the electricity was diminished. Upon this machine, the surface of which was covered, about a foot and a half square with the tin, I put twelve grains of the small Radishes and twenty grains of Lettuce.

These electrified seeds were sown on the same hour of the day, with the like quantity of the same seeds not electrified, taken out of the same parcels, and sown on the same mould; they were covered exactly with the same proportion of earth, placed in the same exposition to the sun, air, and light, and in every respect were treated alike.

March 27th, every one of the twelve *electrified* grains of Radishes appeared.

Whereas at noon on the 28th, nine only of the *non-electrified* began to make their appearance.

March 30th, I saw, at five in the morning, all the *electrified Lettuce,* which announced their having sprouted out during the night.

FOURTH EXPERIMENT.

On the 30th and 31st of March, I electrified twelve hips of a rose-tree, which were taken out of a bundle that for four years had been repeatedly sown without effect. I placed them upon the machine, which I charged with the electric fluid, along with my servant, from eight in the morning until nine at night.

On the evening of the 31st, I put them into a small vessel, containing a certain quantity of water. This apparatus, with the necessary communications, I placed on the above-mentioned machine, which I charged every hour, during nine days.

At the same time twelve non-electrified hips were steeped in water, non-electrified, for the same number of days.

These were afterwards sown in the same mould, similarly exposed in every respect, and on the 19th of April, I discovered, in the morning, a plant of the rose-tree; some others appeared in the evening; and a fifth came up the next day, in the garden-pot containing the electrified hips. But not one of the non-electrified hips ever came out of the ground.

FIFTH EXPERIMENT.

On the 7th of February, I electrified some lupine seeds in three different manners:

1st, By wrapping some up in a sheet of tin, and placing them upon the tableau magique.

2dly, By placing some simply on the tableau magique.

3dly, By giving other several electrical shocks.

On the 7th, 8th, 9th, and 10th, they were electrified by charging the tableau magique at different intervals of time, from morning until evening.

On the 10th, in the evening, these were sown in pots filled with earth.

At the same time a similar quantity of non-electrified lupines were also sown.

Before sowing I made use of the following precaution. I watered the sifted mould, and when it had acquired a due consistence I made holes of

half an inch deep, and placed every seed with the eye downwards. All the vases were alike exposed, and treated in the same way.

On the 18th of February, at five o'clock in the morning, the seeds first enclosed in tin, and electrified, appeared.

At eight o'clock the seeds simply electrified on the tableau magique shewed themselves.

And at ten to eleven those electrified by the shock were visible.

But the non-electrified seeds did not shew themselves until the morning of the 19th.

On the 2d of March it occurred to me to dig up the seeds I had sown in the different pots, and to measure their respective heights.

I took them up with considerable precaution; and I observed at the very first glance that those plants, which were formerly electrified, were considerably larger than the non-electrified.

Upon a more particular examination I found,

1st, That the non-electrified had struck a very little way into the ground, whereas the other had penetrated deep, and had shot out a number of small roots. I counted as many as thirty to one plant electrified in the first manner.

2d, The plants, from the lupins wrapped in tin, during their electrisation, measured from the top of the stalk to the extremity of the root five inches.

3d, One of the plants from the seed, simply electrified on the magic table, measured three inches eight lines and a half, and others three inches six lines.

4th, Those from the seeds, which received the shocks, were two of them four inches and a half, the other three inches ten lines.

5th, The longest of the non-electrified plants were not more than three inches four lines, and on the average not above two inches and a half.

6th, The electrified plants appeared equally healthy with the others.

SIXTH EXPERIMENT.

On the 11th of February I repeated the same experiment with other lupins.

On the 1st of March twenty-six of the seeds electrified on the tableau

magique had vegetated, so as to appear above ground, and the remainder of them made their appearance the next morning.

On the 2d instant I reckoned ten plants from the seeds electrified by shocks, and in the course of the same day the rest appeared.

On the 3d of March, in the evening, some of the non-electrified seeds had vegetated; but it was not until the 4th and 5th of the same month that the rest became visible, at which time

The plants from the seeds, electrified in the first manner, had arrived at the height of eleven lines;

Those of the second were six or seven lines high;

Whilst the non-electrified were not more than from two to four lines high.

SEVENTH EXPERIMENT.

From six o'clock in the morning until twelve at noon, on the 31st of January, 1789, I electrified every half hour fifty grains of the Nasturtium (*Lepidium sativum*), placed on the *magic table*.

At a quarter after twelve, the same day, I sowed them in a vase filled with mould; on the same day, and at the same hour, I sowed, in another vase filled with the same mould, fifty grains of the same plant, taken from the same parcel, but not electrified.

I paid exactly the same attention to both vases; and above all, I took care to place them both absolutely in the same degree of light.

February 2d, about ten o'clock at night, six of the electrified grains of nasturtium rose out of the ground.

February 4th, in the evening, it was before the non-electrified grains appeared.

The difference as to heights, after some days had passed, was sufficiently striking to all to whom I showed them. They at once noticed to the rest, those plants, whose seeds, previous to being sown, had been electrified.

EIGHTH EXPERIMENT.

March 3d, I sowed in two pots, filled with mould, twenty-four grains of rye, twelve grains in each pot.

I took one of the pots, and placed it by itself, making it communicate

with the conductor, by means of a rod of metal. From the 3d of March to the 27th, I every hour, from morning to the evening, gave it an hundred turns with the wheel.

March 15th, in the evening, four grains of *electrified* rye rose, and early the next morning the rest appeared.

March 17, in the evening, two grains of the *non-electrified* rose, and six others appeared early the following day.

March 19, I measured the plants.

Two of the stalks from the *electrified* grain were six lines and a half high, four five lines, and two three lines.

Among the plants from the *non-electrified* grain, two were three lines high, others two lines and a half, and the shortest two lines.

March 26, two of the *electrified* rye plants were four inches and a half high; the greater part of them three inches and a half; and the smaller number two inches eleven lines and a half.

Two of the *non-electrified* plants were three inches and a half; and the rest an inch ten lines and a half. *So that there was a great disproportion between the electrified and non-electrified grains of rye.*

NINTH EXPERIMENT.

March 30. I sowed, in two pots, as much lettuce seed as I could take up between my finger and thumb. I covered them with an equal quantity of mould; after which, I fixed on one of them, and electrified it in the following manner. I insulated it by means of a cake of pitch, a rod of metal descending from the conductor rested upon the vase. I electrified it every hour, with three or four hundred turns of the wheel, and continued this process until April 8th.

April 4th, between five and six o'clock in the morning, the plants came up in the *electrified* pot; and at a quarter after five in the afternoon those in the *non-electrified* pot did the same.

April 8th, at six in the evening, I measured their respective heights.

The electrified Lettuce taken from the top of the stalk to the root.

	Lines.
The highest	21
The greatest number	19
The lesser number	16

The non-electrified Lettuce taken from the top of the stalk to the root.

	Lines.
The highest	18
The greatest number	15
The lesser number	12

Having accomplished this comparison, I next drew out of the ground, just as they happened to stand, six plants of the *electrified* lettuce, with as many of the *non-electrified,* and the result from measurement was as follows:

Length of the electrified Lettuce, taken from where the root and stem join to the extremity of the root.

	Lines.
First	10
Second	18
Third	17
Fourth	15
Fifth	12
Sixth	12

Length of the non-electrified Lettuce, taken from where the root and stem join to the extremity of the root.

	Lines.
First	7
Second	16
Third	13
Fourth	12
Fifth	10
Sixth	8

TENTH EXPERIMENT.

From April 21st, at six o'clock in the morning, until six o'clock in the evening of the 23d, I electrified some grains of lettuce from six o'clock in the morning till nine at night, recharging the *magic table* every hour, and sometimes every half hour.

On the 23d, in the evening, I sowed these three seeds, and at the same time I sowed a like quantity of non-electrified seeds, in the same sort of mould, and taken out of the same paper; the two pots were alike placed, and so was the treatment, as in all my former experiments.

April 28th, by six o'clock in the evening, four plants from the *electrified* seeds came up, as did all the others during the course of the night.

April 29th, in the course of the evening, some of the plants from the *non-electrified* seeds appeared; and on the 30th, the rest did the same.

May 2d, I pulled up, with great precaution, from each of the pots several

plants, as they chanced to stand, with a view to ascertain their respective dimensions. I observed by the first glance,

1st, That the stalks of the *electrified* plants were larger than those of the *non-electrified.*

2dly, That the roots of the *former* appeared longer and bolder; and I found them capable of bearing to be stretched out better than the others, for the *non-electrified* plants broke upon the smallest violence.

The electrified plants measured from the top to the root.	Lines.	*The non-electrified plants measured from the top to the root.*	Lines.
First	14	First	12
Second	13	Second	12
Third	12	Third	11
Fourth	12	Fourth	11
Fifth	12	Fifth	10
Sixth	10	Sixth	12
Seventh	9½	Seventh	9
Eighth	9	Eighth	10
Ninth	10	Ninth	11½
Tenth	10	Tenth	10½
Eleventh	9	Eleventh	10
Twelfth	9½	Twelfth	9½
Thirteenth	8	Thirteenth	9
Fourteenth	7½	Fourteenth	12½
Fifteenth	6	Fifteenth	6

The electrified plants measured from the top of the root to the extremity.	Lines.	*The non-electrified plants measured from the top of the root to the extremity.*	Lines.
First	31½	First	18
Second	37½	Second	22
Third	24½	Third	23
Fourth	28½	Fourth	13
Fifth	25	Fifth	26½
Sixth	29	Sixth	24½
Seventh	27	Seventh	29
Eighth	28	Eighth	26½
Ninth	30	Ninth	27½
Tenth	30	Tenth	30
Eleventh	25½	Eleventh	18
Twelfth	25½	Twelfth	26
Thirteenth	23	Thirteenth	18½
Fourteenth	28½	Fourteenth	18
Fifteenth	22½	Fifteenth	20

It results from this experiment, that in adding the length of these *electrified* plants, to that of their roots, the whole measure amounts to 557½ lines, which divided by 15, gives to each Lettuce 37 lines from the summit of the stalk to the extremity of the root.

In making the like calculation for the *non-electrified* Lettuce plants, the measures amounts only to 496½ lines, which likewise divided by 15, makes each plant 33 lines long.

There exists, therefore, a *difference* of three lines in each plant, between those *electrified* and the *non-electrified,* as proved by comparing the average amounts from the whole.

ELEVENTH EXPERIMENT.

After having taken from each vase the fifteen plants, as mentioned in the former experiment, I placed the vases in the shade, and purposely desisted from giving any water to the remaining plants in order to make an observation of another kind.

May 4th. The *electrified* plants were in just as good a state, as when I had watered them for the last time, April 30th.

The *non-electrified* had suffered exceedingly.

May 6th. The *electrified* Lettuces still retained a fine verdure, but the stalks began to bend down a little.

The *non-electrified* plants were faded, and drooped down on the ground.

May 8th, the *electrified* plants lost a little of their verdure, and the stalks were more bent.

The *non-electrified* plants were become yellow, the stalks white, and quite bent down upon the ground.

May 10th, the *non-electrified* plants were totally dead.

It was May 15th, before the *electrified* plants had completely withered.

TWELFTH EXPERIMENT.

May 7th, I electrified some Mustard Seeds, in doing of which I observed the following process:

I took two pieces of cork, to which I gave three lines in thickness, an

inch and three lines in breadth, by two inches long; I then covered the superficial parts of these corks with some blotting paper that I had moistened, after which I put each piece of cork into a small vase, filled with water, and sowed about sixty seeds of Mustard on each of them.

This vase I electrified from that day to the end of the term, when the experiment was finished; and that from seven in the morning until ten at night.

May 9th, at eight o'clock in the morning I perceived some of the *electrified* seeds had germinated.

At eleven in the morning some of those in the *non-electrified* vase had done the same.

May 10th, I counted twenty-eight of the *electrified* grains had opened.

Eighteen of the *non-electrified* only, had done the same.

In the evening there were thirty-two of the *former*; and only twenty-six of the *latter*.

May 11th, at six in the morning there was upon the cork, in the *electrified* vase, fifty-four grains that had unfolded themselves; and upon the cork in the *non-electrified* vase, the number in that state amounted only to thirty-four.

On that day I measured the plants in the vases.

Electrified Plants.	Lines.	*Non-electrified Plants.*	Lines.
Twenty	6 ... 7	Twenty	4 ... $4\frac{1}{2}$
The rest	4 ... 5	The rest	4 ... $3\frac{1}{2}$

To these most conclusive Experiments in favour of electricity, I shall add but one, taken from the Abbé Bartholon.

THIRTEENTH EXPERIMENT.

After having recorded upwards of fifty experiments, conducted at different seasons, and repeated through different years, all in favour of electricity, the Abbé relates the following, which was made by electrifying the *water* in which he steeped some seeds.

For this purpose I employed, says this able Experimentalist, five small pots of Dutch-ware, each of which I filled with water, and put into it but one kind of seed.

A coating of tin-foil was attached, both inside and outside, to form the electric communication, and the opening of each vase was shut with a cork, carefully varnished.

These five vases were afterwards put into an electric jar, which I had arranged as an *electric magazine,* and its orifice was enclosed by a large cork, covered over its whole surface with sealing-wax: and this cork was bored in the middle to receive a glass hollow tube, which descended to the bottom of the jar. The whole was afterwards varnished with green wax.

This apparatus was *electrified* for two days, with the exception of the nights. After the second day, the seeds were sown in the open ground in the same part of the garden, in little squares, divided each into two parts, A and B, for the seeds, which were *electrified,* and for those not so. Precaution was taken that every circumstance should resemble: hence the seeds were taken out of the same bag, these were shaken together, before they were taken out, and divided into two parcels, and they were put into similar pots, but placed out of the electric communication. Of each sort ten grains were sown. I observed in the pots marked,

A. The LUPINS *electrified* opened the ground on the *fifth* day after being sown, about two o'clock, and by seven o'clock seven of the same seeds began to appear, the cotyledons becoming visible. On the *sixth* day the remainder appeared like the rest in the morning. On the *seventh* day, the cotyledons were more open, and separated, and discovered the leaves of the plume. By the *eighth* day, these leaves were progressively developed, and gradually increased in size.

B. The LUPINS *not electrified,* did not appear before the *seventh* day in the morning, and then only three; in the evening two others shewed themselves. On the *eighth* day in the morning, four others, the remainder at twelve the same time. Their developement was progressive, but all the ten did not advance equally with the others.

Not to fatigue my readers with too much repetition of the same kind, I

shall only observe, that from all these comparative experiments it appeared, that the VETCHES, BEANS, PEAS, &c. in the electrified water rose a day or two before those in the *simple* water, and were advanced accordingly.

The influence of *positive* or *vitreous electricity*,* says Dr. Darwin in his Phytologia, in forwarding the germination of plants and their growth, seems to be pretty well established; though some doubts on this head were raised by Dr. Ingenhousz.

The Abbé D'Ormey not only found various seeds to vegetate sooner, and to grow taller, which were put upon his insulated table, and supplied with electricity, as did the two Roziers; but also that silk-worms † began to spin much sooner, which were kept electrified, than those of the same hatch, which were kept in the same place and manner, except that they were not electrified.

The Abbé Bartholon, who had before written a tract on this subject, and proposed several ingenious methods for applying electricity to agriculture and gardening, has also repeated a numerous set of experiments, and shews that *natural electricity*, as well as the *artificial*, increases the growth of plants, and the germination of seeds, and opposes Dr. Ingenhousz by very numerous and conclusive facts. Vide Journal de Physique, par Rozier, tom. xxxv. p. 270, and p. 401.

FOURTEENTH EXPERIMENT.

MY friend, Mr. D. Bilsbourne, continues Dr. Darwin, in June 1797, sowed some MUSTARD seeds in four garden pots at Mr. Hartop's at Dalby Hall in Leicestershire. He subjected one of these to *positive* or *vitreous electricity*, and another *negative* or *resinous electricity*,‡ and observed that the seeds in the pot subjected to the *negative* or *resinous electricity* germinated a day

---

* Vide Note ‡, p. 157.

† Acard of Berlin raised the eggs of silk-worms by means of the electric fluid, as also those from the hen, (vide Bonnet's Contemplation of Nature) and Spalanzani found that the fecundated spawn of the frog was in the same manner vivified by the electric fluid, and this philosopher observes, " they grew faster than those that were not electrified," an event which exactly corresponds with the acceleration of vegetation occasioned by the electric fluid. (See Dissertation II.)

‡ Vide Dr. Darwin's Temple of Nature, or Origin of Society, p. 46, where will be found a long dissertation on the subject of these two electricities.

before those in the two pots, which were *not electrified,* but otherwise exposed to some circumstances.

It appears, says the celebrated Cavallo, from the observations which have been made on the electricity of the atmosphere, that Nature makes great use of this fluid in promoting vegetation.

1. In the spring, when seeds begin to sprout, then temporary electrical clouds appear, and pour forth electric rain. The electricity of the clouds and rain continues to increase, till that part of the autumn in which the last fruits are gathered.

2. It is this fluid which collects the vapours, forms clouds, and is then employed to disorder and dissipate them in rain. It gives fire to common moisture, by the help of which it actuates and animates vegetation.

3. From this principle may be explained the old proverb, " that no watering gives the country so smiling a look as rain." The clouds of rain by extending their electric atmosphere to the plants, dispose the pores of the latter to receive with greater facility the water which is impregnated with this penetrating and diluting fluid.

Ventinat in his *Tableau du regne vegetal,* vol. i. in confirmation of this doctrine, says, notwithstanding the ingenious manner in which Dr. Ingenhousz* has endeavoured to overthrow the belief of the importance of electricity

* One of the arguments used by Dr. Ingenhousz against the beneficial effects of electricity on vegetation, is the well known rapid growth of plants in Egypt, where there seldom appears any rain. It has been argued in many places of this work, that Nature is seldom prodigal; and where less stimulation was wanted, there the different operating agents were not found so abundant. Heat and moisture sufficiently combine here to produce this rapid increase, and the plentiful dews, which fall every evening, would at any rate compensate for the loss of electric showers. I shall take this opportunity of calling the attention of my readers to a very singular production of the electric fluid, which is frequent in the sultry regions adjoining to the Egyptian shores. Bruce, the discoverer of the source of the Nile, thus describes this wonderful natural phænomenon. " In that vast expanse of desert, from the west to the north-west of us, we saw," says this traveller, " many prodigious *moving pillars of sand* at different distances, at times darting forward with great celerity, at others, stalking on with a majestic slowness; at intervals we thought they were coming in a very few minutes to overwhelm us; and flying particles of sand did actually more than once reach us. Again they would retreat, and diminishing by degrees, at length disappear. The tops of these pillars seemed to reach the very clouds. Sometimes a separation would take place, and the pillars would become disjointed, when presently they dispersed in air, and appeared no more. About noon they began to advance with considerable swiftness upon us, the wind being very strong at north: eleven of them ranged along-side of us, probably, at the distance of three miles. Their greatest diameter, as far as one could judge, from sight, might be about ten feet. These appeared at intervals during the whole of the day. As the evening was drawing in, and the sun was setting, they produced a superb Temple, and his rays shining through

to vegetation, the well known increase of some plants after thunder-storms leaves us no longer in doubt on this subject. Dauberton mentions, that he

---

them, gave them all the appearance of *pillars of fire.* They now approached nearer to us, within two miles. It was in vain to think of flying; the swiftest horse, or fastest sailing ship, could be of no use to carry us out of this danger; this persuasion rivetted us to the spot where we were to sleep, creating an impression on the mind, to which I can find no name, though surely one ingredient in it was fear, with a considerable deal of wonder and astonishment."

Water-spouts at sea, like *whirlwinds* by land, known also in hot climates, arise likewise from the electric fluid. These commonly begin with a cloud, which appears very small, and which mariners call the squall, which augments in a little time into an enormous cloud of a cylindrical form, or that of a reversed cone, and produces a noise like an agitated sea, sometimes emitting thunder and lightning, and also large quantities of rain or hail, sufficient to inundate large vessels, overset trees and houses, and every thing which opposes its violent impetuosity.

Tournefort thus describes this strange phænomenon. " The first I ever saw," says this traveller, " was about a musket-shot from our ship. There we perceived the water begin to boil, and to rise about a foot above its level. The water was agitated and whitish; and above its surface there seemed to stand a smoke, such as might be imagined to come from wet straw before it begins to blaze. It made a sort of a murmuring sound, like that of a torrent heard at a distance, mixed, at the same time, with an hissing noise, like that of a serpent: shortly after we perceived a column of this smoke rise up to the clouds, at the same time whirling about with great rapidity. It appeared to be as thick as one's finger; and the former sound still continued. When this disappeared, after lasting for about eight minutes, upon turning to the opposite quarter of the sky, we perceived another, which began in the manner of the former; presently after a third appeared in the west; and instantly beside it still another arose. The most distant of these three could not be above a musket-shot from the ship. They all continued like so many heaps of wet straw set on fire, that continued to smoke, and to make the same noise as before. We soon after perceived each, with its respective canal, mounting up in the clouds, and spreading, where it touched the cloud, like the mouth of a trumpet. These canals were of a whitish colour, and so tinged, as I suppose, by the water which was contained in them; for, previous to this, they were apparently empty, and of the colour of transparent glass. These canals were not straight, but bent in some parts, and far from being perpendicular, but rising in their clouds with a very inclined ascent. But what is very particular, the cloud to which one of them was pointed happening to be driven by the wind, the spout still continued to follow its motion, without being broken; and passing behind one of the others, the spouts crossed each other, in the form of a St. Andrew's cross. In the beginning they were all about as thick as one's finger, except at the top, where they were broader, and two of them disappeared; but shortly after, the last of the three increased considerably; and its canal, which was at first so small, soon became as thick as a man's arm, then as his leg, and at last thicker than his whole body. We saw distinctly, through this transparent body, the water, which rose up with a kind of spiral motion; and it sometimes diminished a little of its thickness, and again resumed the same; sometimes widening at top, and sometimes at bottom; exactly resembling a gut filled with water, pressed with the fingers, to make the fluid rise, or fall; and I am well convinced, that this alteration in the spout was caused by the wind, which pressed the cloud, and impelled it to give up its contents. After some time its bulk was so diminished as to be no thicker than a man's arm again; and thus, swelling and diminishing, it at last became very small. In the end, I observed the sea which was raised about it to resume its level by degrees, and the end of the canal that touched it to become as small as if it had been tied round with a cord; and this continued till the light, striking through the cloud, took away the view. I still, however, continued to look, expecting that its parts would join again, as I had before seen in one of the others, in which the spout was more than once broken, and yet again came together; but I was disappointed, for the spout appeared no more."

is acquainted with a gardener, who always washes off the electric showers by a plentiful dilution with common water to hinder his lettuces from running to seed, which otherwise they would do. A practical hint derived from one not conscious of theory.

Dews advance vegetation from this source.

Electricity augments the natural evaporation of fluids, and especially of those fluids which are most subject to evaporation of themselves; and it has also a great effect on fluids, when the vessels containing them are non-electrics. If a humid body, a sponge for instance, be placed upon a conductor positively electrified, the evaporation will go on much more rapidly, and it will be much sooner dry, than a similar body differently circumstanced.

When water is passing out of small tubes in a continued stream, if these be electrified, the whole escapes in fine sprays, and evaporates in the form of dew.

Signor Volta has observed, that water in a state of evaporation, as when thrown upon hot coals, produces always negative electricity.

There are many operations of Nature constantly carrying on, which escape the ordinary observations of mankind, but when known excite the highest sense of astonishment.

The evaporation of water, and the fall of dew is of this nature.

Who could have conjectured, says the learned Bishop of Landaff,* that an acre of ground, even after having been parched by the heat of the sun in summer, dispersed into the air above 1600 gallons of water in the space of twelve of the hottest hours of the day? No vapour is seen to ascend, and we little suppose that in the hottest part of the day, more usually does ascend than in any other. The experiment from which I draw this conclusion, is so easy to be made, that every one may satisfy himself of the truth of it.

FIRST EXPERIMENT.

On the 2d of June, 1779, when the sun shone bright and hot, I put a large drinking glass, with its mouth downwards, upon a grass-plat which was mown close; there had been no rain for above a month, and the grass was

* Vide Chemical Essays, vol. iii.

become brown; in less than two minutes the inside of the glass was clouded with a vapour, and in half an hour drops of water began to trickle down its inside, in various places. This experiment was repeated several times with the same success. That I might accurately estimate the quantity, thus raised, in any certain portion of time, I measured the area of the mouth of the glass, and found it to be twenty square inches: there are 1296 square inches in a square yard, and 4840 square yards in a statute acre; hence, if we can find the means of measuring the quantity of vapour raised from twenty square inches of earth, suppose in one quarter of an hour, it will be an easy matter to calculate the quantity which would be raised with the same degree of heat, from an acre in twelve hours. The method I took to measure the quantity of vapour, was not perhaps the most accurate which might be thought of, but it was simple and easy to be practised: when the glass had stood on the grass-plat one quarter of an hour, and had collected a quantity of vapour, I wiped its inside with a piece of muslin, the weight of which had been previously taken; as soon as the glass was wiped dry, the muslin was weighed again, its increase of weight shewed the quantity of vapour which had been collected. The medium increase of weight, from several experiments made on the same day, between twelve and three o'clock, was six grains collected in one quarter of an hour, from twenty square inches of earth. If the reader takes the trouble to make the calculation, he will find that above 1600 gallons, reckoning eight pints to a gallon, and estimating the weight of a pint of water at one pound avoirdupois, or 7000 grains troy weight, would be raised, at the rate here mentioned, from an acre of ground in 24 hours.

The immense quantity of exhalation from the seas surrounding our globe is still more astonishing. Dr. Hally, by observing the quantity evaporated from a vessel full of water of the same degree of saltness with that of the ocean, calculated, that the quantity exhaled from the *Mediterranean Sea* alone, in one summer's day, there being little wind, amounted to 5,280,000,000 tons of water.

SECOND EXPERIMENT.

It may easily be conceived, that the quantity thus elevated will be greater when the ground has been well soaked with rain, provided the heat be the

same; I did not happen to mark the heat of the ground when I made the fore-mentioned experiment; the two following are more circumstantial: the ground had been wetted the day before I made them by a thunder-shower, the heat of the earth, at the time of making them, estimated by a thermometer laid on the grass, was ninety-six degrees; one experiment gave 1973 gallons from an acre in twelve hours, the other gave 1905. Another experiment made, when there had been no rain for a week, and the heat of the earth was 110 degrees, gave after the rate of 2800 gallons from an acre in twelve hours.

The quantity of water which was condensed on the inside of the glass, I found to be accurately proportionable to the time during which it stood on the grass; for in one experiment six grains were collected in ten minutes, and in another fifteen grains were collected in twenty-five minutes; now the proportion of six to ten is the same as that of fifteen to twenty-five.

In order to see whether the copious vapour collected by the glass was owing to the natural perspiration of the grass, or to a kind of mechanical distillation from the body of the earth, I put the glass upon a footpath which was dry, and had no grass growing upon it, the vapour rose from the footpath as well as from the grass, but not so abundantly.

THIRD EXPERIMENT.

Upon the same grass-plat, and contiguous to the glass used in these experiments, I placed a silver cup, with its mouth downwards, of a shape similar to that of the glass, and nearly of the same dimensions; but I could never observe that its inside had collected the least particle of vapour, though I frequently let it stand on the grass for half an hour or more.

FOURTH EXPERIMENT.

By means of a little bees wax, I fastened an half crown very near, but not quite contiguous, to the side of the glass, and setting the glass, with its mouth downwards, on the grass, it presently became covered with vapour, except that part of it which was near to the half crown. Not only the half crown itself was free from vapour, but it had hindered any from settling on the glass

which was near it, for there was a little ring of glass surrounding the half crown to the distance of one-fourth of an inch which was quite dry, as well as that part of the glass which was immediately under the half crown; it seemed as if the silver had repelled the water to that distance.

SIXTH EXPERIMENT.

A large red wafer had the same effect as the half crown; it was neither wetted itself, nor was the ring of glass contiguous to it wetted. A circle of white paper produced the same effect, so did several other substances, which it would be tedious to enumerate.

These phenomena, respecting the different disposition of different bodies to attract the rising vapour, are similar to what others have taken notice of concerning the *falling* of *dew*, and are, probably, to be explained upon the same principles.

SEVENTH EXPERIMENT.

Muschenbroek placed on the leaden terrace of the Observatory at Utrecht, vessels of glass, china, varnished wood, polished brass, and pewter: he found that in the course of a night the glass, china, and varnished wood, had collected a great abundance of dew, but that not a drop had fallen on any of the polished metals. M. du Fay likewise exposed to the air, when the dew was falling, two large funnels, one made of glass, the other of polished pewter; the necks of the funnels being inserted into vessels proper to retain any moisture which might be collected by them; he sometimes found in the morning that the vessel under the glass funnel contained an ounce or more of water, but he never observed so much as a single drop in the other.

CONCLUSION.

Hence the effects of dews, and of thunder showers, confirm yet more the prevailing opinion, that electricity accelerates the evolution and growth of seeds.

SECT. XX.

ON DARKNESS AS FAVOURABLE TO GERMINATION.

> Even the weak *Embryo,* ere to life it breaks,
> From HIS high pow'r its slender texture takes;
> While in HIS book the various parts inroll'd,
> Increasing, own eternal *Wisdom's* mould.
>
> SMART.

THAT light and heat, are distinct bodies though often conjoined, was known to the Honourable and Illustrious Mr. Boyle.

In general, a very considerable degree of heat is requisite to the emission of light from any body; but there are several exceptions to this, especially in light proceeding from putrescent substances and phosphorus, together with that of luminous animals, and other similar appearances. Light proceeding from putrescent animal and vegetable substances, as well as from glow-worms, is mentioned by Aristotle. Thomas Bartholin mentions four kinds of luminous insects, two with wings, and two without; but in hot climates travellers say they are found in much greater numbers, and of different species. Columna, an industrious naturalist, observes, that their light is not extinguished immediately upon the death of these animals.

The first distinct account that we meet with of light proceeding from putrescent animal flesh is that which is given by Fabricius ab Aquapendente; who says, that when three Roman youths, residing at Padua, had bought a lamb, and had eaten part of it on Easter day 1592, several pieces of the remainder, which they kept till the day following, shone like so many candles when they were casually viewed in the dark. Part of this luminous flesh was immediately sent to Aquapendente, who was professor of anatomy in that city. He observed that both the lean and the fat of this meat shone with a whitish kind of light; and also took notice, that some pieces of kid's flesh, which had happened to have lain in contact with it, was luminous, as well as

the fingers and other parts of the bodies of those persons who touched it. Those parts, he observed shone the most which were soft to the touch, and seemed to be transparent in candle light; but where the flesh was thick and solid, or where a bone was near the outside, it did not shine.

After this appearance, we find no account of any other similar to it, before that which was observed by Bartholin, and of which he gives a very pompous description in his ingenious treatise already quoted. This happened at Montpelier in 1641, when a poor old woman had bought a piece of flesh in the market, intending to make use of it the day following. But happening not to be able to sleep well that night, and her bed and pantry being in the same room, she observed so much light come from the flesh as to illuminate all the place where it hung. A part of this luminous flesh was carried as a curiosity to Henry Bourbon, duke of Condé, the governor of the place, who viewed it for several hours with the greatest astonishment.

This light was observed to be whitish; and not to cover the whole surface of the flesh, but certain parts only, as if gems of unequal splendor had been scattered over it. This flesh was kept till it began to putrify, when the light vanished; which, as some religious people fancied, it did in the form of a cross.

It is natural to expect, that the almost universal experimental philosopher Mr. Boyle should try the effect of his air-pump upon these luminous substances. Accordingly we find that he did not fail to do it; when he presently found that the light of rotten wood was extinguished *in vacuo,* and revived again on the admission of air, even after a long continuance *in vacuo*; but the destruction of this light was not so complete immediately upon exhausting the receiver, as some little time afterwards. He could not perceive, however, that the light of rotten wood was increased in condensed air; but this he imagined might arise from his not being able to judge very well of the degree of light, through so thick and cloudy a glass-vessel as he then made use of; but found that the light of a shining fish, which was put into a condensing engine before the Royal Society, in 1668, was rendered more vivid by that means. The principal of Mr. Boyle's experiments were made in October 1667.

This philosopher attended to a great variety of circumstances relating to this curious phenomenon. Among other things he observed, that change of air was not necessary to the maintenance of this light; for it continued a long

time when a piece of the wood was put into a very small glass hermetically sealed, and it made no difference when this tube which contained the wood was put into an exhausted receiver. This he also observed with respect to a luminous fish, which he put into water, and placed in the same circumstances. He also found that the light of the shining fishes had other properties in common with that of shining wood; but the latter, he says, was presently quenched with water, spirits of wine, a great variety of saline mixtures, and other fluids. Water, however, did not quench all the light of some shining veal on which he tried it, though spirit of wine destroyed its virtue presently.

Mr. Boyle's observation of light proceeding from fresh meat was quite casual. On the 15th of February 1662, one of his servants was greatly alarmed with the shining of some veal, which had been kept a few days, but had no bad smell, and was in a state very proper for use, The servant immediately made his master acquainted with this extraordinary appearance; and though he was then in bed, he ordered it to be immediately brought to him, and he examined it with the greatest attention. Suspecting that the state of the atmosphere had some share in the production of this phenomenon, he takes notice, after describing the appearance, that the wind was south-west and blustering, the air hot for the season, the moon was past its last quarter, and the mercury in the barometer was at 29^{3} inches.

Mr. Boyle was often disappointed in his experiments on shining fishes; finding that they did not always shine, in the very same circumstances, as far as he could judge, with others which had shined before. At one time that they failed to shine, according to his expectations, he observed that the weather was variable, and not without some days of frost and snow. In general he made use of whitings, finding them the fittest for his purpose. In a discourse, however, upon this subject at the Royal Society in 1681, it was asserted that of all fishy substances, the eggs of lobsters, after they had been boiled, shone the brightest. Olig. Jacobœus observes, that upon opening a sea-polypus, it was so luminous, as to startle several persons who saw it; and he says that the more putrid the fish was, the more luminous it grew. The nails also, and the fingers of the persons who touched it, became luminous; and the black liquor which issued from the animal, and which is its bile, shone also, but with a more faint light.

Mr. Boyle draws a very minute comparison between the light of burning coals and that of shining wood or fish, showing in what particulars they

agree, and in what they differ. Among other things he observes, that extreme cold extinguishes the light of shining wood, as appeared when a piece of it was put into a glass tube, and held in a frigorific mixture. He also found that rotten wood did not waste itself by shining, and that the application of a thermometer to it did not discover the least degree of heat.

There is a remarkable shell-fish called Pholas, which forms for itself holes in various kinds of stone, &c. That this fish is luminous, was noticed by Pliny; who observes, it shines in the mouth of the person who eats it, and if it touch his hands or cloaths, makes them luminous. He also says that the light depends upon its moisture. The light of this fish has furnished matter for various observations and experiments to M. Reaumur, and the Bolognian academicians, especially Beccarius, who took so much pains with the subject of phosphoric light.

M. Reaumur observes, that, whereas other fishes give light when they tend to putrescence, this is more luminous in proportion to its being fresh; that when they are dried, their light will revive if they be moistened either with fresh or salt water, but that brandy immediately extinguishes it. He endeavoured to make this light permanent, but none of his schemes succeeded.

The attention of the Bolognian academicians was engaged to this subject by M. F. Marsilius, in 1724, who brought a number of these fishes, and the stones in which they were inclosed, to Bologna, on purpose for their examination.

Beccarius observed, that though this fish ceased to shine of itself when it became putrid; yet that in its most putrid state, it would shine, and make the water in which it was immersed luminous, when it was agitated. Galeatius and Montius found, that wine or vinegar extinguished this light; that in common oil it continued some days; but in rectified spirit of wine or urine, hardly a minute.

In order to observe in what manner this light was affected by different degrees of heat, they made use of a Reaumur's thermometer, and found that water rendered luminous by these fishes increased in light till the heat arrived to 45 degrees; but that it then became suddenly extinct and could not be revived.

In the experiments of Beccarius, a solution of sea-salt increased the light of the luminous water, a solution of nitre did not increase it quite so much.

Sal ammoniac diminished it a little, oil of tartar *per deliquium* nearly extinguished it, and the acids entirely. This water poured upon fresh calcined gypsum, rock chrystal, ceruss, or sugar, became more luminous. He also tried the effects of it when poured upon various other substances, but there was nothing very remarkable in them. Afterwards, using luminous milk, he found that oil of vitriol extinguished the light, but that oil of tartar increased it.

This gentleman had the curiosity to try how differently coloured substances were affected by this kind of light; and having, for this purpose, dipped several ribbons in it, the white came out the brightest, next to this was the yellow, and then the green; the other colours could hardly be perceived. It was not, however, any particular colour, but only light that was perceived in this case. He then dipped boards painted with the different colours, and also glass tubes, filled with substances of the different colours, in water rendered luminous by the fishes. In both these cases the red was hardly visible, the yellow was the brightest, and the violet the dullest. But on the boards the blue was nearly equal to the yellow, and the green more languid; whereas in the glasses, the blue was inferior to the green.

Of all liquors into which he put the pholades, milk was rendered the most luminous. A single pholas made seven ounces of milk so luminous, that the faces of persons might be distinguished by it, and it looked as if it was transparent.

Air appeared to be necessary to this light; for when Beccarius put the luminous milk into glass tubes, no agitation would make it shine, unless bubbles of air were mixed with it. Also Montius and Galeatius found, that, in an exhausted receiver, the pholas lost its light, but the water was sometimes made more luminous; which they ascribed to the rising of bubbles of air through it.

Beccarius, as well as Reaumur, had many schemes to render the light of these pholades permanent. For this purpose he kneaded the juice into a kind of paste, with flour, and found that it would give light when it was immersed in warm water; but it answered best to preserve the fish in honey. In any other method of preservation, the property of becoming luminous would not continue longer than six months, but in honey it lasted above a year; and then it would, when plunged in warm water, give as much light as ever it had done before.

Similar, in some respects, to those observations on the light of the pholas, was that which was observed to proceed from wood which was moist, but not in a putrid state, which was very conspicuous in the dark.

That the sea is sometimes luminous, especially when it is put in motion by the dashing of oars and the beating of it against a ship, has been observed with admiration by a great number of persons. Mr. Boyle, after reciting all the circumstances of this appearance, as far as he could collect them from the accounts of navigators; as its being extended as far as the eye could reach, and at other times being visible only when the water was dashed against some other body; that in some seas this phenomenon is accompanied by some particular winds, but not in others; and that sometimes one part of the sea will be luminous, when another part, not far from it, will not be so; concludes with saying, that he could not help suspecting that these odd phenomena, belonging to great masses of water, were in some measure owing to some cosmical law or custom of the terrestrial globe, or at least of the planetary vortex.

Some curious observations on the shining of some fishes, and the pickle in which they were immersed, were made by Dr. Beal, in 1765; and had they been properly attended to and pursued, might have led to a discovery of the cause of this appearance. Having put some boiled mackerel, together with salt and sweet herbs; when the cook was, some time after, stirring it, in order to take out some of the fishes, she observed, that, at the first motion, the water was very luminous; and that the fish shining through the water added much to the light which the water yielded. The water was of itself thick and blackish, rather than any other colour; and yet it shined on being stirred, and at the same time the fishes appeared more luminous than the water. Wherever the drops of this water, after it had been stirred, fell to the ground, they shined; and the children in the family diverted themselves with taking the drops, which were as broad as a penny, and running with them about the house. The cook observed, that, when she turned up that side of the fish that was lowest, no light came from it; and that, when the water had settled for some time, it did not shine at all. The day following, the water gave but little light, and only after a brisk agitation, though the fishes continued to shine, as well from the inside as the outside, and especially about the throat, and such places as seemed to have been a little broken in the boiling.

When in the light of the sun, he examined, with a microscope, a small piece of a fish which had shined very much the night before, he found nothing remarkable on its surface, except that he thought he perceived what he calls a *steam,* rather dark than luminous, arising like a very small dust from the fish, and here and there a very small and almost imperceptible sparkle. Of the sparkles he had no doubt; but he thought it possible that the steam might be a deception of the sight, or some dust in the air.

Finding the fish to be quite dry, he moistened it with his spittle; and then observed that it gave a little light, though but for a short time. The fish at that time was not fetid, nor yet insipid to the best discerning palate. Two of the fishes he kept two or three days longer for farther trial: but the weather being very hot, they became fetid; and, contrary to his expectations, there was no more light produced either by the agitation of the water or in the fish.

Father Bourzes, in his voyage to the Indies in 1704, took particular notice of the luminous appearance of the sea. The light was sometimes so great, that he could easily read the title of a book by it, though he was nine or ten feet from the surface of the water. Sometimes he could easily distinguish, in the wake of the ship, the particles that were luminous from those that were not; and they appeared not to be all of the same figure. Some of them were like points of light, and others such as stars appear to the naked eye. Some of them were like globes, of a line or two diameter; and others as big as one's head. Sometimes they formed themselves into squares of three or four inches long, and one or two broad. Sometimes all these different figures were visible at the same time; and sometimes there were what he calls *vortices* of light, which at one particular time appeared and disappeared immediately like flashes of lightning.

Nor did only the wake of the ship produce this light, but fishes also, in swimming, left so luminous a track behind them, that both their size and species might be distinguished by it. When he took some of the water out the sea and stirred it ever so little with his hand, in the dark, he always saw in it an infinite number of bright particles; and he had the same appearance whenever he dipped a piece of linen in the sea, and wrung it in a dark place, even though it was half dry; and he observed that when the particles fell upon any thing that was solid, it would continue shining for some hours together.

After mentioning several circumstances which did not contribute to this appearance, this Father observes, that it depends very much upon the *quality of the water*; and he was pretty sure that this light is the greatest when the water is fattest, and fullest of foam. For in the main sea, he says, the water is not every where equally pure; and that sometimes if linen be dipped in the sea, it is clammy when it is drawn up again: and he often observed, that when the wake of the ship was the brightest, the water was the most fat and glutinous, and that linen moistened with it produced a great deal of light, if it was stirred or moved briskly. Besides, in some parts of the sea, he saw a substance like saw-dust, sometimes red and sometimes yellow; and when he drew up the water in those places, it was always viscous and glutinous. The sailors told him, that it was the spawn of whales; that there are great quantities of it in the north; and that sometimes, in the night, they appeared all over of a bright light, without being put in motion by any vessel or fish passing by them.

As a confirmation of this conjecture, that the more glutinous the sea-water is, the more it is disposed to become luminous, he observes, that one day they took a fish which was called a *bonite,* the inside of the mouth of which was so luminous, that without any other light, he could read the same characters which he had before read by the light of the wake of the ship; and the mouth of this fish was full of viscous matter, which, when it was rubbed upon a piece of wood, made it immediately all over luminous; though, when the moisture was dried up, the light was extinguished.

The abbé Nollet was much struck with the luminousness of the sea when at Venice in 1749; and, after taking a great deal of pains to ascertain the circumstances of it, concluded that it was occasioned by a shining insect; and having examined the water very often, he at length did find a small insect, which he particularly describes, and to which he attributes the light. The same hypothesis had also occurred to M. Vianelli, professor of medicine in Chioggia near Venice; and both he and M. Grizellini, a physician in Venice, have given drawings of the insects from which they imagined this light to proceed.

The abbé was the more confirmed in his hypothesis, by observing, some time after, the motion of some luminous particles in the sea. For, going into the water, and keeping his head just above the surface, he saw them dart from the bottom, which was covered with weeds, to the top, in a manner which he

thought very much resembled the motions of insects; though, when he endeavoured to catch them, he only found luminous spots upon his handkerchief, which were enlarged when he pressed them with his finger.

The dissimilarity of light and heat is evinced by this simple circumstance; that as light gives no heat to transparent bodies, which the emanations from a fire do, there is reason to believe them to be different fluids. Thus when smoke is blown near the focus of a large burning glass, it does not ascend; which shews that the air is not heated and rarefied by it; though it would burn or vitrify in an instant any opake body which might be opposed to it; but the emanations of heat from a fire soon rarefy and warm the air in its vicinity, causing it to ascend, as may be seen by a spiral card-vann placed over a chimney-piece, and which is agreeably seen in the use of the new glass fire-screens of Parisian invention, which placed before a parlour fire permit the rays of light to pass, but intercept the emanations of fluid heat.

For the better imbibing of caloric, or the matter of heat, the vegetable mould is of a dark colour nearly black, and that this is most favourable for that intention is shewn by the following experiment.

EXPERIMENT.

During the hot weather, which we had in the latter end of June and the beginning of July, 1772, I made an experiment at Cambridge, which I then thought no more of, but which an accident brought to my mind again; and I now venture to relate an account of it, in hopes that some philosophical friend will take the trouble of prosecuting it. I exposed, says the Bishop of Landaff, the bulb of an excellent thermometer to the direct rays of the sun, when the sky was perfectly free from clouds; the mercury rose 108° of Fahrenheit's scale, and continued stationary. A fancy struck me, to give the bulb a black covering; this was easily effected by a camel's hair pencil and Indian ink; the mercury fell a few degrees during the application of the coating, and the evaporation of the water; but presently after rose to 118°, or 10° in consequence of the black coat with which I had covered that part of the bulb which was exposed to the sun.

The air, which is a bad conductor of electricity, is known also to be a bad conductor of heat; and thence prevents the heat acquired from the sun's rays

by the earth's surface from being too soon dissipated, in the same manner as a blanket, which may be considered as a sponge filled with air, prevents the escape of heat from the person wrapped in it.

That heat is indispensible towards germination is known to every one. During the cold winter, the vessels are closed, the fluids are torpid, and these are only to be excited in the proper season when the " penetrative sun" rouses the embryo from its slumber into animated life. But, on the contary, light is unfavourable, as depriving the seeds of the oxygen, so necessary to stimulate its first actions.

The fine experiments of Scheele and Berthollet have shewn that the absence or presence of light has a surprising effect upon the result of chemical experiments.

Light disengages oxygen air from the nitric acid, the oxygenated marine acid, &c. It reduces the oxyds, or calces of gold, silver, &c. It changes the nature of oxygenated muriates, according to the observations of Berthollet.

Hence it may likewise be supposed to deprive the seed of what rouses it into action, namely its oxygen.

That light impedes germination was first shewn by Dr. Ingenhousz.

FIRST EXPERIMENT.

I placed, says this admirable philosopher, in the open air exposed to the sun, 60 seeds of mustard, placed equally distant, on an island of cork, floating on a glass vessel, full of water, and the sides of the glass were left exposed.

SECOND EXPERIMENT.

In the second, the apparatus was placed in a window in a room. The window shut.

THIRD EXPERIMENT.

In a similar apparatus, the glass was covered with black paper.

FOURTH EXPERIMENT.

In a fourth, the apparatus was put in the room, in the shade.

FIFTH EXPERIMENT.

In a fifth, wholly excluded from the light.

RESULT.

In twenty-four hours some grains had already begun to push out the radicle, in the third, fourth, and fifth experiments.

In forty-eight hours the radicles appeared in the second apparatus.

On the third day, all had radical leaves, except the first.

On the fourth day, the radicle in the first appeared in a few seeds only; all the others were destroyed.

In experiment first, exposed to the full action of the sun the seeds might seem to have suffered from a too great degree of heat; but the seeds in the third apparatus had undergone a greater degree of heat; for the first shewed 82 degrees of heat, the second was at 86, and the third at 92 degrees.

They each advanced exactly in proportion to the exclusion of light.

These experiments were so often repeated, and always with the same result, that there no longer remains any ground for doubt.

The abbé Bertholon suspected, that the quicker vegetation of seeds arose from the quantity of water being greater in the one case than the other. Senebier, to determine this point, made the following experiment.

SIXTH EXPERIMENT.

He placed pease, beans, and french beans, upon sponges, which had imbibed an equal degree of water, inclosed in tin vessels of a determinate size, covered with cemented glass.

Some of these cases were painted in the inside, of a red colour. They were all exposed to the same influence of the sun.

The water which might evaporate from the sponges was prevented from escaping, so that, upon this ground, there could be no source of deception.

But the germination proceeded much more rapidly in the darkened cages, than in those which were exposed to the influence of the light.

SEVENTH EXPERIMENT.

In other cases in a darkened chamber, where an increased heat could not have excited the germination, as in those exposed to the sun, here the germination was even more rapid than in the other instances.

CONCLUSION.

Light therefore must be considored as unfavourable to germination.

SECT. XXI.

ON THE VITALITY OF SEEDS.

First, if you can, *celestial Guide!* disclose
From what fair fountain varied *life* arose,
Whence the fine nerve to move and feel assign'd,
Contractile fibre, and ethereal mind?—
" GOD, THE FIRST CAUSE!—*in this terrene abode*"
Young NATURE cries, (who is the child of God)
" *From embryon births the changeful forms improve,*
" *Grow, as they live, and strengthen as they move!*"

DARWIN.

THE Deity hath implanted the power of attraction into mineral bodies, and given life, or vitality, to the two other Kingdoms of Nature.

In what life consists is as much a mystery as attraction itself. When called into action we at once acknowledge this extraordinary principle, but when lying dormant, as in the seed, we feel at first loth to acknowledge it.

To exemplify what is meant by this principle when in a dormant state, the illustrious Haller, speaking of Mosses, says, " that they appear to possess the privilege almost of immortality, for after being dried in books, and kept in them for two or three hundred years, solely by being macerated in water, they are restored to their pristine life and vigour *, which experiments I repeated with some of the Mosses in the herbarium of the Bauhines."

* I cannot forbear mentioning *here* some account of a small microscopical animal, which Lewenhoeck has named *rotifer* (wheel-polypus). All the observers, even the most modern ones, that have succeeded him, have believed that this animal has real wheels; but to be certain of the contrary, it is only necessary to place it betwixt two pieces of glass, and then observe it with an excellent microscope. It is a small gelatinous worm, commonly found in the earth or sand, collected by rain in the tops of houses. I have likewise found it in other earths, as well as in waters that have been some time stagnant, and more frequently again in those that have a very gentle current, and are filled

Thus the seeds of many plants retain their vital power for incalculable years, only requiring the agents of heat, moisture, and air, to put this principal into action, and make it self-evident to our senses.

Our ideas of life have been so much connected with organic bodies, and principally those endowed with visible action, that it requires a new bend to the mind, to make it conceive that these circumstances can be separable.

An organ is a peculiar construction of parts to answer some purpose, the operation of which may depend upon such a configuration, but mere organization can do nothing, even in mechanics it must still have something corresponding to the living principle, some power.

Brown, the Reformer of Medicine, calls life a forced state, and therefore makes life to consist of action, whereas sometimes it is quiescent, but susceptible of action from adapted stimuli, and of consequent alterations, both in the organization and modes of action.

Lamark entertains an opinion somewhat similar.

"Jusqu'au moment de la *germination,* toutes les parties d'une semence qui se trouve séparée de la plante-mère qui l'a produite, sont en quelque sorte dans un repos complet: les sucs qu'elle renferme y sont en quantité médiocre,

---

with conferva and other aquatic plants. This worm is divided towards its head into two pretty large trunks, which appear like two wheels or stars, from the number of small, extremely sharp, and short branches that are attached to their circumference. These really appeared to Lewenhoeck to be wheels of a rare mechanism, and every one would judge the same, on seeing the creature put them in motion. But a more exact observation at length convinced me that they are not wheels, but composed of a quantity of small moveable arms, formed like pointed cones, and planted all round the two trunks. It lets fall these moveable arms or rays successively, and afterwards raises one after the other with so much celerity, that the eye fancies they are turning round like the spokes of a coach wheel, or rather, like the branches of a wheeled fire-work. It never moves these two wheels, except when it swims or wishes to eat, and these two states are invariably the shortest of its life. In swimming, it strikes the water with these arms or branches with great celerity, rests itself at different periods, and thus transports itself from one place to another. When it eats, it, on the contrary, fixes its tail in some substance, and afterwards turns its two wheels, giving such a motion to the water, that it directs the course of it towards its head, so that it presents to its mouth all the small corpuscles with which it is filled.

The Wheel-Polypus loses, like the moss, when dried, all appearance of life, but recovers the same when immersed in water. I have left it, says Fontana, by way of experiment, in a very dry soil, and exposed it, during the summer, to the whole heat of the sun, for the space of two years and an half. I afterwards returned it again into water, where at the end of two hours, it recovered life and motion. I put one of them on a piece of glass, which I exposed, during a whole summer, to the noonday sun; it there became so dry, that it was like a piece of hardened glue. A few drops of water did not, however, fail to restore its motion and life.

Thus the microscopical eels that are found dry and withered in smutty wheat, recover motion and life as soon as they are wetted with a little water, and again become lifeless and dry, whenever they are no longer moistened. I have repeatedly assured myself of this with an extreme pleasure.

sans action, sans mouvement; et l'on peut conjecturer qu'il existe un equilibre parfait entre l'action et la reaction des diverses parties qui la composent. Alors la plantule ou l'embryon végétal, qui constitue la partie essentielle de cette semence, ne peut être considéré *ni comme jouissant de la vie*, car elle n'existe point sans mouvement organique, *ni comme en étant totalement dépourvue*; car ce qui la constitue peut être suspendu, et il l'est effectivement avant la germination si toutefois il existe. La *vie* alors n'attend qu'un stimulus particulier, et qu'un premier mouvement communiqué aux tendres organes de la plantule, pour jouir d'une existence active, et commencer à opérer les développemens qui résultent de son action." *

John Hunter was the first, I believe, who proved the vitality of Eggs. I had long supposed, says this illustrious Physiologist, that the principle of life was not wholly confined to animals, or animal substance endowed with visible organization and spontaneous motion; but believed that the same principle might exist in animal substances, devoid of apparent organization and motion.

I was led to this opinion about twenty years ago, when busied in making observations on the growth of the chick in the process of incubation. I then observed, that whenever an egg was hatched, the yolk (which is not diminished in the time of incubation) was always perfectly sweet to the very last; and that the part of the albumen, which has not been expended on the growth of the animal, some days before hatching, was also perfectly sweet, although both were kept in a heat of 103° in the hen's egg for three weeks, and in the duck's for four; and I observed, that if an egg was not hatched, that egg became putrid in nearly the same time with any other dead animal substance. To determine how far eggs were possessed of a living principle I made the following experiments.

---

* Until the period of *germination*, all the parts of a seed which are separate from the mother plant, are in a sort of complete repose; the contained fluids are in moderate quantity, without action, or movement; and we may suppose, that the equilibrium betwixt action and reaction of the different component parts is equal. Then the plantule, or essence of the seed, *cannot be said to possess life*, for this depends upon organic movement; nor can it be said *to be altogether deprived of life*, for this principle may be suspended, and is altogether so, before germination, *if indeed in that state it can be allowed to exist. Life* then would depend upon a proper *stimulus*, and this producing the first movements to the tender organs of the *plantule*, endows it afterwards with active existence, and the future developement which ensues.

FIRST EXPERIMENT.

After having placed an egg in a cold about 17°, till it froze, I allowed it to thaw; by which process it was to be supposed that the preserving powers of the egg must be destroyed. I then put *this egg* into a frigorific mixture,* and with it *one newly laid,* and found the difference in freezing was seven minutes and a half, the fresh one resisting so much longer time the powers of cold.

SECOND EXPERIMENT.

A new laid egg being put into a cold atmosphere, fluctuating between 17° and 15°, took above half an hour to freeze; but when thawed and put into an atmosphere at 25°, it froze in half the time. This experiment was repeated frequently with nearly the same result.

To ascertain the comparative degree of heat between a living and a dead egg, and also to determine whether a living egg be subject to the same laws with the more imperfect animals, I made the following experiment.

THIRD EXPERIMENT.

A fresh egg, and one which had been frozen and thawed, were put into the cold mixture at 15°: the thawed one soon came to 32°, and began to swell and congeal; the fresh one sunk to 29° and a half, and in twenty-five minutes later than the dead one, it rose to 32°, and began to swell and freeze.

In this experiment, the effect on the fresh egg was similar to that produced on the frog, eel, snail, &c. where life allowing the heat to be diminished two or three degrees below the freezing point, afterwards resisted all

---

* The cold was first produced by means of ice and snow with sal ammoniac or sea-salt, to about the 10° of Fahrenheit's thermometer: ice was then mixed with spirit of nitre; but what degree of cold was then produced I did not, says John Hunter, examine. This cold mixture was made in a tub surrounded with woollen cloths, and covered with the same, to prevent the effects of the heat of the atmosphere upon the mixture itself, and to preserve as much as possible a cold atmosphere within the vessel.

further decrease; but the powers of life were expended by this exertion, and then the parts froze like any other dead animal matter."

CONCLUSION.

" From these experiments it appears, that a fresh egg has the power of resisting heat, cold, and putrefaction, in a degree equal to many animals, and it is more than probable, continues John Hunter, that this power arises from the same principle in both."

" Snakes and fishes," continues the same ingenious experimentalist, "after being *frozen,* having still retained so much of life, as when *thawed* * to resume their vital action, is a fact so well attested, that we are bound to believe it."

In like manner seeds retain their vital principle, although subjected to vast changes of temperature. " Great degrees of *heat,*" says the illustrious Dr. Smith, † " short of boiling, do not impair the vegetative power of seeds, nor do we know any degree of *cold* that has such an effect." Hence it is, " that if seeds be not exposed to too great an artificial heat, so as completely to scorch them," according to the experience of a very expert botanist, Mr. Salisbury, " they cannot be kept in too warm a situation."

Upon this principle it was, that when the smut ‡ pervaded in a dreadful

* In this way eels are said to be transported frozen from Moscow to Petersburgh, and re-animated by the gradual application of heat.

† Vide " An Introduction to Physiological and Systematic Botany," p. 99.

‡ This disease is produced by an *insect,* according to the observations of Mr. Somerville, in the second volume of Communications to the Board of Agriculture, where he relates, that some years ago he collected a quantity of smutted ears from one field of wheat, in which they were very numerous, and a number of healthy well-filled ears from another field, in which there was no smut. The grains were rubbed out of both, intimately mixed, and kept in a box for two months, at the end of which they were rubbed between the hands in such a manner as to break the whole of the smut ball. The parcel was then divided into two equal parts, one of which was three or four times washed with pure water, and well rubbed between the hands at each washing, and afterwards sown in a drill in his garden; the other half was sown in another drill without any washing or preparation whatever; the soil, and every other circumstance, was equal. Both parcels vegetated at the same time, and for about two months thereafter there was no visible difference in their appearance; about that period he, however, observed that many of the plants in the drill that had been sown without being washed, were of a darker colour than the others; these, when narrowly examined, were of a dirty green. The plants in the drill that had been washed were all of one colour, and seemingly healthy; as the season advanced, the difference in colour became more striking, and continued to increase till the grain was fairly out of the blade; about which time many of the dirty green ears began to exhibit symptons of decay. As soon as the ear was fairly shot out, the whole of those in the unwashed drill, that had the dirty green appearance before described, were found to contain nothing but smut; and these smutted ears were in the proportion of more than six to one of the healthy ones; while, on the contrary, the drill in which the washed grains had been sown, and

degree, the corn throughout France, Mons. Tillet discovered, that the insect which infests the grains, producing this disease, are to be killed by a degree of heat not injurious to the corn, and he constructed, at the expense of

---

which consisted of several hundred grains, had hardly a smutted or unhealthy grain in it. The same experiment was repeated the following season, and with nearly the same result. Satisfied with knowing that complete washing would be found a remedy for the disease, he made no farther enquiry upon the subject till last autumn, when he was employed in making observations upon the blight, in the course of which he met with a good deal of smut in many fields; and being at the time possessed of some excellent glasses, he carefully examined some of the smutted plants. This at first was done more as a matter of amusement, than from an expectation of discovering any thing that might throw light upon the subject. Upon a near inspection with the glass, he found that the dirty green colour of the blades of the smutted ears was owing to a number of spots, infinitely small, and bearing a near resemblance to those upon blighted ears: his observations were continued throughout the whole period of the ripening, in the course of which he made no additional discovery, except observing that the leaves and stalks of the smutted ears decayed sooner than such as were healthy.

About the end of autumn, however, having one day brought home some smutted ears of rather an unusual appearance, he examined them very narrowly, and observed that the balls were perforated in many places with small round holes, a thing he had not before observed in any that he had met with: this he ascribed to vermin; and upon sticking one of the grains upon a pin, and placing it under the glass in a very bright sun, he could distinctly observe several small transparent specks upon the beard, or downy part of it. He examined several more, and met with exactly the same appearance; but being called hastily away upon business, he was under the necessity of leaving them upon the table, without being able to ascertain whether the objects he had seen were eggs or insects. In the evening when he came home, he resumed the investigation by *candle-light*; in the course of which, as he was under the necessity of holding them very near the candle, the heat soon relieved him from his embarrassment, by putting them in motion, and he then discovered that the specks above mentioned were real insects, resembling wood-lice in shape. Next day he repeated the same trials by sun-light with new smut-balls, and discovered the same appearances, but without being able to make any of the insects stir. Disappointed and vexed at not being able to see them in motion with sun-light, and recollecting the heat of the candle, he threw the concentrated rays of the sun upon them with a burning-glass, which completely answered his purpose of putting them in motion, and shewing them in every point of view. To describe minutely an insect so small as not to be distinguishable by the naked eye, would, says he, be no easy matter; it is sufficient to say, that its general appearance is very similar to a wood-louse, though infinitely smaller.

As soon as he was clearly ascertained of the existence of this insect, his mind was, he says, perfectly at ease with regard to the cause of the distemper; but though he could very readily conceive that vermin, in the early stages of the growth of a plant, might so injure the stamina as to render it unfit to produce any thing but smut, he could not so well understand how it was possible for the mere touch of the black earth contained in the smut-balls to produce the same effect.

After some reasoning he, however, gives it as his opinion that smut is occasioned by the small insect above described, as seen by the glass in the downy part of the grain; and that when the balls are either broken in the operation of thrashing, or come in contact with clean healthy grains, the insects leave the smutted grains, and, adhering to such as are healthy, are sown with them, and wound the tender stem in such a manner as to render the plant incapable of producing any thing but smut.

The grains of smutty corn are tender, and filled with a black stinking powder, instead of the white flour which sound grain contains. As these grains are very easily broke, they spread their powder on the sound grains, which having on their extremity a little tuft of hairs, the powders stick there. Farmers distinguish the wheat thus vitiated, by saying that *it is blacked in the point*, (in French *qu'il a le bout*) and bakers avoid it, because it gives their bread a violet or purple hue.

government, *ovens,** into which the diseased corn was put, and it came out free from this disease, and capable, when sown, of germinating.

It may yet be doubted how far this drying of the seed may exhale parts † which serve as the first nourishment of the embryo plantule: for as

---

As soon as the stalks begin to rise, if the blades are opened so as to discover the young ear, it will be found to be already distempered; and in this case, the pith or inside of the stalk likewise appears sometimes black.

As soon as the ear appears out of the covering which the blades form, it looks shrunk. All the coverings of the grain are so altered and shrivelled, that the smut appears through them. As the powder in such grains has little cohesion, it is easily washed away by the rains, or carried off by the wind. If any of it remains, it is only on the points of the sound grain.

When corn thus *blacked in the point* has been kept for several years, and frequently sifted through an iron sieve, this colour vanishes. It may also be taken off immediately, by rubbing it with a cloth: which shews that the impression is only superficial.

* This idea might probably be derived from our own illustrious countryman Tull, who recommends a mode of preserving wheat by drying it on a hair-cloth in a *malt-kiln,* with no other fuel but clean straw, and no greater heat than that of the sunshine. In this situation the wheat remained from four hours to twelve hours, according to the previous dampness of it. Mr. Tull knew a farmer in Oxfordshire, who purchased wheat when it was cheap, and kept it by thus drying it for many years, and made a large fortune by selling it again in dearer seasons. The life of the seed was not destroyed by this process; as he asserts that some of it grew which had been kept in this manner seven years.

Darwin, in his Phytologia, p. 363, says, some time ago an insect called a corn-butterfly committed great ravages in France while in its vermicular state, so as to ruin two hundred parishes. A cure for it was at length discovered, which consisted in drying the wheat in an *oven* before sowing it, and thus exposing it to such a degree of heat as would destroy the eggs of the insect without injuring the seed. Was not this disease the smut?

† Dr. Darwin, in his Phytologia, says, (Sect. xvi. 4.) Where the fruit which surrounds any kind of seeds can be sowed along with them, it may answer some useful purpose. Thus the fruit of crabs, quinces, and some hard pears, will lie all the winter uninjured, covered only with their autumnal leaves, and will continue much to nourish their germinating seeds in the spring. So the holly-berry and the ivy-berry remain during the winter months uninjured by the rains or frosts, and undevoured by birds or insects, and contribute to nourish their germinating seeds, when they fall on the ground in the spring. The acrid husk of walnuts sowed along with them, preserves the sweet kernel from the attack of insects; the same must be the use of the acrid oil of the cashew-nut. The hawthorn possesses both a nutritive covering and a hard shell for the above purposes; and the seeds of roses are armed with stiff, pointed bristles, as well as furnished with a nutritious fruit, so long known as an agreeable conserve in the shops of medicine, conserva cynosbati; the former constitutes a defence against insects, and the latter supplies a reservoir of nutriment for the germinating seeds.

Thus Mr. Sneyde of Belmont in Staffordshire, having observed some seeds, which came accidentally among raisins, to grow readily, directed many different seeds to be sent from the West Indies covered with raisins, and others in sugar, and others of the same kind in the usual manner of sending them, and found that those immersed in sugar or covered with raisins, looked extremely well, and grew readily; whereas many of the other sorts had lost all vegetative power.

Miller also observes, that seeds made dry and kept dry in bags, retain for a long time their vegetative property; whilst the same, when packed up in bottles closely corked and sealed, will not grow.

Hence it is probable, that even in seeds, as with fruits, some fermentation or vital action is going on, and we observe in an egg a reservoir for air—and the aperture near the hilum may be for the admission of air, for seeds that have been varnished are found not to vegetate.

Doctor Darwin observes in his Phytologia, "Cucumbers and melons are best if kept for some time, as they therefore shoot out less vigorously, and thence become more fruitful. But this principle may be carried too far* by some gardeners, who say these seeds *cannot be too old,* and even assert ten years to be a proper boundary. Hence it is new seeds come up sooner and with greater certainty, and grow more luxuriantly."

The durability, or dormant vital power in some seeds, is hardly to be calculated. In the Bath Society's paper, vol. v. p. 464, there is an account of the seeds of *Indian wheat,* which grew extremely well after having been kept upwards of *thirty-four* years, as was accurately ascertained. Some seeds in an herbarium, an *hundred and twenty* years old or more, have been made to germinate by moistening them first in the oxygenated muriatic acid.†

Concerning the vitality of seeds, says Professor Barton, I have little hesitation in supposing that different kinds of seeds, if imbedded in stone or dry earth, and removed far from the influence of air and moisture, might be made to retain their vegetative quality for a *thousand* years. The growth of plants in places newly dug up, not witnessed for centuries,‡ seems to confirm this opinion. "If the ground in old established botanic gardens," says Dr. Smith, "be dug much deeper than ordinary, it frequently happens that different species which have been long lost are recovered, from their seeds being latent in the soil, as I have been assured by Mr. Fairburn, superintendant of Chelsea garden, and others."

---

* *Peas* and *beans* will germinate very well at seven years of age; but the smaller seeds, as those of *lettuce* and *kidney-beans,* Mr. Marshall says, in his Treatise on Gardening, are not to be depended upon after the first year.

† Vide Experiment X, p. 81 of this volume.

‡ Vide page 39 of this volume.

SECT. XXII.

TIME OF THE EVOLUTION OF SEEDS.

See in corruption, all surprizing state,
How struggling life eludes the stroke of fate;
Shock'd at the scene, though sense averts its eye,
Nor stops the wond'rous process to descry;
Yet juster thought the mystic change pursues,
And with delight ALMIGHTY wisdom views!

BOYSE.

A pigeon sits upon her eggs a fortnight; an hen, three weeks; a duck, goose, and turkey, a month.*

So it is with seeds; these differ in their precise periods of evolution.

The *millet* (MILIUM), and *wheat* (TRITICUM), vegetate in one day; *kidney-bean, mustard,* and *spinach,* in three days; *lettuce* and *fennel* (ANETHUM FŒNICULUM), in about four days; *cucumber, gourd,* and others, in five days; *beet* and *radish* in six days; *barley* in seven days; *orache* (ATRIPLEX, in eight days; *cabbage* in ten days; *common beans* (FABA), fifteen days; *onion,* nineteen days; and *parsley* (PETROSELINUM) from forty to fifty days. Of the common garden seeds, I believe there are none which take a shorter time to vegetate than several of the cruciform tribe of plants, such as *mustard* and *turnip*; nor any, I think, a longer time than *parsley.* The long torpidity of the last mentioned seed, has given rise to a vulgar proverb, "that *parsley* goes nine times to the devil, before it comes up."

The seeds of many vegetables take a whole year to vegetate: such as the *peach,* the *almond,* the *walnut,* the *chesnut,* the *piony* (PÆONIA OFFINALIS), different species of *canna,* or *Indian reed,* and others. Other seeds require two years before they vegetate, such as the *common dogwood* (CORNUS FLORIDA), the *filbert* (CORYLUS AVELLANA), and the *common papaw,*

* TIMES OF GESTATION IN SOME ANIMALS. The Elephant, 2 years. Camel, 1 year. Horse, 11 months. Cow, 9 months. Stag, 8 months. Goat, 5 months. Hog, 4 months. Wolf, 73 days. Dog, 63 days. Cat, 56 days. Hedgehog, 40 days. Hare, 30 days. Guinea-pig, 21 days.

or *custard apple* (ANNONA TRILOBA), and some even a longer period than this. *

The spring is the season when this vitality in seeds is especially called forward. A certain action, however, goes on even during the autumnal and winter months, which prepares for the grand metamorphosis. Thus the seeds of the *monkshood* (ACONITUM) and many other plants, require to be previously sown in autumn, when these appear the following spring, for if sown in spring, they remain from that time till the next spring for want of this action.

But with respect to seeds, the period of their germination may be greatly advanced.

The application of an *hot-bed* † is known to all: but the most remarkable effect is that produced from the *oxygenated muriatic acid.* ‡

The seeds of *common cress* (LEPIDIUM SATIVUM), germinated after six or seven hours, when put into the oxygenated muriatic acid; § whereas, when lying in common water, they required from 36 to 38 hours.

Humboldt discovered that all other seeds obeyed the same law. They all germinated beyond expectation. It is necessary to take the seeds out as soon as the corcule appears. That the seeds are not impaired by the acid, is proved by the many plants that have been treated in this way, under the inspection of Jacquin, and in which vegetation goes on wonderfully well, though many of them had their seeds steeped in the oxygenated muriatic acid.

---

* Vide Barton's Elements of Botany.

† Bradley, in his New Improvements of Planting and Gardening, p. 67, gives us the following receipt. " Provide a bushel of *bran*, in which, after having mixed your seeds, wet the whole well with rain or pond water. In about three days it will begin to heat, and so continue to ferment, and when dry pour upon it some warm water, which repeat as may be found necessary, this will greatly accelerate the germination of all seeds, and I am indebted for this new artificial heat from the incomparable Sir *Isaac Newton*, to whom every art is greatly obliged." The use of *tan* pits is upon the same principle.

‡ Vide Sect. XXII. of this work, p. 77.

§ As the oxygenated muriatic acid is not readily procured by gardeners, Humboldt recommends an easy process for producing it. Take a cubic inch of water, a teaspoon-full of common muriatic acid, two teaspoonsful of powdered manganese, mix them well together, and place the seeds in them. Apply an heat from 18—30″ of Reaumur.

SECT. XXIII.

COMPARISON OF THE SEED WITH THE EGG.

Then Nature's births enclosed in *egg* or *seed*,
From the tall forest to the lowly weed,
Her beaux and beauties, butterflies and worms,
Rise from *aquatic* to *aerial* forms.
——So erst, as Egypt's rude designs explain,
Rose young DIONE from the shoreless main;
Type of organic nature! source of bliss!
Emerging beauty from the vast abyss!
Sublime on chaos born, the goddess stood,
And smiled enchantment on the troubled flood;
The warring elements to peace restored,
And young Reflection wonder'd and adored.

DARWIN.

FROM the accurate experiments and observations of Spallanzani it appears, that in *rush-broom* (SPARTIUM JUNCEUM), the very minute seeds were discerned in the pod at least twenty days before the flower was in full bloom; that is, twenty days before fecundation. At this time also the powder of the anthers was visible, but glued fast to their summits. The seeds however at this time, and for ten days after the blossom had fallen off, appeared to consist of a gelatinous substance.

On the *eleventh* day after the falling of the blossom, the seeds became heart-shaped, with the basis attached by an appendage to the pod, and a white point at the apex; this white point was on pressure found to be a cavity including a drop of liquor.

On the *twenty-fifth* day the cavity, which at first appeared at the apex, was much enlarged, and still full of liquor; it also contained a very small semi-transparent body of a yellowish colour, gelatinous, and fixed by its two opposite ends to the sides of the cavity.

In a *month* the seed was much enlarged, and its shape changed from a heart to a kidney; the little body contained in the cavity was increased in bulk, and was less transparent and gelatinous, but there yet appeared no organization.

On the *fortieth* day the cavity, now grown larger, was quite filled with the body, which was covered with a thin membrane; after this membrane was removed, the body appeared of a bright green, and was easily divided by the point of a needle into two portions, which manifestly formed the two lobes; and within these, attached to the lower part, the exceedingly small plantule was easily perceived.

The foregoing observations evince, 1. That the seeds exist in the ovarium many days before fecundation. 2. That they remain for some time solid, and then a cavity containing a liquid is formed in them. 3. That after fecundation a body begins to appear within the cavity fixed by two points to the sides, which in process of time proves to be two lobes containing a plantule. 4. That the ripe seed consists of two lobes adhering to a plantule, and surrounded by a thin membrane, which is itself covered with a husk or cuticle.

The analogy between seeds and eggs has long been observed, and is confirmed by the mode of their production. The egg is known to be formed within the hen long before its impregnation. C. F. Wolf asserts, that the yolk of the egg is nourished by the vessels of the mother, and that it has from those its arterial and venous branches; but that after impregnation these vessels gradually become impervious and obliterated; and that new ones are produced from the fœtus, and dispersed into the yolk. The young seed after fecundation I suppose is nourished in a similar manner from the gelatinous liquor, which is previously deposited for that purpose; the germen of the plant producing or secreting it into a reservoir or amnios, in which the embryo is lodged; and that the young embryo is furnished with vessels to absorb a part of it, as in the very early state of the embryo in the egg.

Another curious analogy seems to exist between the embryo of the seed and of the egg in their mode of suspension. The cicatricula of the egg rests on the yolk, which is suspended by two points, called chalazæ, somewhat above its center of gravity; whence, however the egg is moved, this embryo is always kept upwards, probably the better to receive the warmth of the mother during incubation. The seed-embryo seems to be supported in the same manner by the above relation of Spallanzani by two points, and may thus receive a greater warmth from the summer sun.

Hence the seeds of vegetables are a sexual offspring, corresponding with the eggs of animals, and contain, like them, not only the rudiment of the

new organization, but also a quantity of aliment laid up for its early nourishment.

The eggs of birds contain two kinds of albumen, or white, one less viscid than the other, which is first consumed, and the yolk or vitellum, which is drawn up into the bowels of the chick at its exclusion from the shell, and serves it for nourishment a day or two, till it can learn to select and digest grains or insects. In like manner many seeds are furnished with two kinds of nourishment, the mucilaginous or oily meal of the seed-lobes, and the saccharine or acescent pulp of the fruit, as in pears, plums, and cucumbers, which supply nutriment to the embryo plant, till it is able to strike into the earth sufficient roots for the purpose of absorbing its nutritious juices.

The spawn of fish, and of frogs, and of insects, as of snails and bees, which are almost as innumerable as the seeds of plants, and are in the same manner excited into life by the warmth of the sun, are analogous to those seeds, I believe, which are not surrounded with fruit, and which contain but one kind of nourishment for the embryo plant, as grains of corn, and legumes; but perhaps these have not yet been sufficiently attended to by philosophers.

These eggs of animals and seeds of vegetables are produced by the congress of male and female organs; the former supplying the speck of animation or cicatricula in the egg, and the corculum or heart in the seed; and the latter producing the nidus, or nest for its reception, and the nutritive material for its first support. Thus the eggs of fowls are formed long before they are impregnated, and are sometimes laid in their unimpregnated state; and the seeds of legumes are visible many days before the flower opens, and in consequence before they are impregnated, as before observed.

The eggs of birds contain a bag of air at their broad end for the purpose of oxygenating the blood of the chick. In this one circumstance the seeds of plants seem to differ from the eggs of birds, as they contain no air-bag, though it is probable they may agree with the spawn of fish, which I suppose possess no included air. When the seeds fall on the ground in their natural state of growth, or are buried an inch or two beneath the soil, which has recently been turned over, and thus contains much air in its interstices, their coats do not continue dry like the shells of eggs during incubation, but immediately become moist membranes, like the external membrane of the spawn of fish immersed in water, and in consequence can

admit the oxygenation of the air through them to an adapted set of arteries on their internal surface, according to the curious observations of Dr. Priestley on the oxygenation of the blood by the air through the moist membranes of the lungs.

It should be here observed, that many seeds, before they fall on the moist earth, are included in a bag of air, as those of the staphylea, (bladder-nut); of the physalis alhekengi, (winter-cherry); of colutea, (bladder-senna); in the pods of peas and beans; in the cells surrounding the seeds of apples and pears; and in the receptacle of ketmia, which probably serves to oxygenate the blood of the infant seed, which in these plants may thus be of forwarder growth, before it is shed upon the soil.

There exists a series of glands, and their ducts, improperly called umbilical vessels by some writers, which supplies the seed with nourishment from the parent plant, so long as it adheres to the ovarium of its mother, as the vessels by which a pea adheres to the pod, in which it is included; in fruits and nuts, where the kernel is covered with a stone or shell, a long cord of vessels passes into the bottom of the stone or shell, and rising to the top bends round the lobes of the kernel, and is inserted near or into the corculum or heart of the seed, where the living principle resides, and affords not only present nutrition to the vegetable embryo, but also secretes the farinaceous or oily materials for its future nourishment, which constitute the cotyledons of the seed.

But the vessels, which may be properly called umbilical, pass from the heart or corculum of the seed, which is the living embryo of the future plant, into the seed-lobes, commonly called cotyledons, and imbibe from thence a solution of the farinaceous or oily matter there deposited for the nutriment of the new vegetable. These vessels are delineated in their magnified appearance by Dr. Grew, and are by him termed seminal roots.

These umbilical vessels probably consist of a system of absorbents, which supply nutriment to the embryo plant from the cotyledons of the seed, and also of a system of placental arteries and veins spread on the humid membrane, which covers the cotyledons, and is moistened by its contact with the earth, for the purpose of oxygenating the vegetable blood. This idea is countenanced by many plants bringing up their cotyledons, or seed-lobes, out of the ground into the air, which are then converted into leaves, and perform the office of lungs, after they have given up beneath the soil the nutriment which they previously contained, as in the young kidney-bean,

(phaseolus); so the white corol of the helleborus niger, (christmas rose) is changed into a green calyx by losing one system of arteries after the impregnation of the seeds.

The seed-embryo therefore resembles the chick in the egg, first as when vivified by the influence of external warmth they both begin their growth by the absorbent system of vessels being stimulated into action by their adapted nutriment; and the fluids thus pushed forwards stimulate into action the other parts of the system, consisting at first principally of arteries and glands.

First, they seem much to resemble each other in their possessing each of them an absorbent system of vessels, which imbibe the nutritious matters laid up for them in the albumen or white of the egg, and in the cotyledons or lobes of the seed; and also of a placental system of arteries for the purpose of oxygenating their fluids, as described above in the seed, and which appears in the egg to be spread on a membrane which covers the white, as is shewn in the plates of Malpighi, and called by him the chorion, and exposes the blood of the chick to the oxygen of the air contained at the broad end of the egg through a moist membrane.

The use of the large apparent artery spread on the cotyledons of a germinating seed of a garden-bean, called seminal roots by Grew, as shewn in Plate I. fig. 1, and that spread on the chorion of the chick in the egg, so called by Malpighi, and shewn in tom. ii. fig. 54, and by Fabricius ab Aquapendente, tab. i. fig. 13, which must be an artery, as it carries red blood, are believed to be respiratory organs, like the placental vessels of the fœtus of viviparous animals, because the cotyledons of some seeds rise out of the ground, and become leaves, after the nutriment they contained is expended, and are then called seminal leaves, as in the kidney-bean, (phaseolus); and because those which do not rise out of the ground perish beneath the soil as soon as the young plant gains its leaves, which are its aerial respiratory organs.

Secondly, the chorion of the chick consists of a membrane including the white, or albumen, and is not only in contact with the air-bag at the broad end of the egg, which, as the chick advances, covers more than half of the internal surface of the shell, but also with the membrane which lines all the other part of the shell, as appears in our plate, which is copied from Malpighi: yet this extensive chorion, with the numerous arteries and veins which are spread upon its surface, is not drawn up into the body of the chick like the yolk and its including membrane, but perishes at the nativity

of the chick like the placental vessels of the fœtus of viviparous animals; or sometimes, I suppose, before its nativity, as the chick perforates the air-bag, and is heard to chirp, before it is excluded from the shell.

Hence it would appear, that both the artery attending the seminal roots above mentioned, and this artery on the chorion of the chick, must perform some more important office than to supply nourishment to the coats of the absorbent vessels, which imbibe the mucilage of the seed, or the white of the egg, and which absorbents must themselves possess their proper vasa vasorum. And what more important office can they have than that of oxygenating the blood of the vegetable or animal embryo? And this becomes more probable as they both perish at its nativity like the placenta and cotyledons of viviparous animals.

As the incubation of the chick advances, it differs from the seed-embryo in the production of intestines, with a stomach, on the internal surfaces of which the mouths of the absorbents now terminate; and lastly, in the production of a mouth and throat to receive and swallow the remainder of the albumen, in which it swims; whereas the seed-embryo shoots down new roots into the earth with an absorbent system to acquire its nutriment, as that from the cotyledons of the seed becomes exhausted.

Nor is there any thing similar to the yolk of the egg found in the seeds of vegetables, which is drawn up into the intestines of the young chick about the time of its exclusion from the shell to serve it with nutriment for a day or two, till it can learn of its parent by imitation to select and swallow its adapted food. Nor is the fœtus of viviparous animals furnished with any thing similar to the yolk of oviparous ones, as they have milk ready prepared for their first nutriment in the breast of the mother.

As soon as the new foliage of the plant rising out of the ground becomes expanded, and the root descending penetrates the earth with its ramifications, the umbilical systems of vessels cease to act, both the absorbents, which previously supplied the young embryo with nutriment from the cotyledons, and also the placental artery, which was spread on the exterior membrane of the cotyledons for the purpose of oxygenation. These vessels now either coalesce and decay beneath the soil, or wither and fall off, when raised above it in the form of seed-leaves.

The seeds of plants are thus a sexual or amatorial progeny, produced principally by the male part of the flower, and received into a proper nidus, and supplied with nutriment by the female part of it.

SECT. XXIV.

OF THE MOTIONS OF THE PLUMULA AND ROSTEL.

In earth, sea, air, around, below, above,
Life's subtle woof in Nature's loom is wove;
Points glued to points a living line extends,
Touch'd by *some goad* approach the bending ends;
Rings join to rings, and irritated tubes
Clasp with young lips the nutrient globes or cubes;
And urg'd by *appetencies new*, select,
Imbibe, retain, digest, secrete, eject.
In branching cones the living web expands,
Lymphatic ducts, and convoluted glands;
Aortal tubes propel the nascent blood,
And lengthening veins absorb the refluent flood.
Leaves, lungs, and gills, the vital ether breathe
On earth's green surface, or the waves beneath.

DARWIN.

PLANTS present us with some circumstances which seem to indicate that they have feeling; but I do not know whether we are in a proper situation to observe them, or whether the strong persuasion we have so long entertained of their being insensible, will permit us to judge rightly of them. In order to this, we must be a *carte blanche* on the question, and bring plants to a new trial, both more important and more exempt from prejudices. An inhabitant of the moon, who has the same senses and the same share of understanding with ourselves, but who is not prepossessed concerning the insensibility of plants, is the philosopher we are seeking for.

Imagine that such an observer had lately studied the productions of our earth, and that after having bestowed his attention on polypuses and other insects which multiply by slips, he proceeds to the contemplation of vegetables. He would undoubtedly trace them from their origin. For this purpose he would sow seeds of different species, and would attentively observe their springing up. Suppose some of these seeds had been sown the contrary way, the radicle being turned upwards, and the *plumula,* or little stalk, downwards. We will likewise suppose that our observer knows how to distinguish between the radicle and the *plumula,* and is acquainted

with the functions of both. After some days he will remark, that the radicle will raise itself to the surface of the earth, and the *plumula* will sink down into it. He will not be surprised at this direction, so prejudicial to the life of the plant: he will impute it to the position he gave to these seeds when he sowed them. He will pursue his observations, and will soon see the radicle fold back on itself, in order to gain the inside of the earth, and the *plumula* bend backwards in like manner, in order to raise itself into the air. This change of direction will appear to him very remarkable, and he will begin to suspect that the organized being he has been studying is endued with some discernment. Nevertheless, being too wise to pronounce his opinion on these first indications, he will suspend his judgment, and pursue his inquiries.

The plants, whose coming up our natural philosopher has been observing, received their birth near a covert. Being favoured by this situation, and cultivated with care, they made a considerable progress in a short time. The earth, which encompasses them at some distance, is of two very opposite qualities. That part on the right side of the plants is moist, rich, and spongy; that on the left is dry, hard, and gravelly. Our observer remarks, that the roots, after having begun to extend themselves pretty equally on both sides, changed their course, and directed themselves entirely towards that part of the soil which is fat and moist. They even lengthened to such a degree, as made him apprehensive they would intercept the nourishment from the neighbouring plants. To prevent this inconvenience, he contrives to make a ditch, which separates the plants he is observing from those they threaten to famish, and thus thinks he has provided against all events. But these plants, which he flatters himself to have so easily mastered, elude his prudence: they cause their roots to pass under the ditch, and conduct them to the other side.

Surprised at this, he uncovers one of these roots, but without exposing it to the heat: he holds a sponge towards it filled with water. The root soon inclines itself towards this sponge. He several times shifts the place of the latter; the root follows it, and conforms to all its positions.

Thus the integuments of the seed, having fulfilled their destined office of protection, burst and decay. The young root, or rostel, is the first part of the infant plant that comes forth, and by an unerring law of Nature is sent downwards to seek out nourishment, as well as fix the plant to the ground.

The cause productive of such movement has been attempted to be explained by several philosophic writers. Darwin thus endeavours to unfold this mystery.

When the seed falls naturally upon the earth, or is buried artificially in shallow trenches beneath the soil, the first three things necessary to its growth are heat, water, and air. Heat is the general cause of fluidity, without which no motion can exist; water is the menstruum, in which the nutriment of vegetable and animal bodies is conveyed to their various organs; and the oxygen of the atmosphere is believed to afford the principle of excitability so perpetually necessary to all organic life; and which renders the living fibres both of the vegetable and animal world obedient to the stimuli which are naturally applied to them.

Whence we may in some measure comprehend a difficult question; why the plume of a seed sowed upon, or in the earth, should ascend, and the root descend, which has been ascribed to a mysterious instinct; the *plumula* is stimulated by the air into action, and elongates itself, where it is thus most excited; and the *radicle* is stimulated by moisture, and elongates itself thus, where it is most excited, whence one of them grows upwards in quest of its adapted object, and the other downward.

Hunter, when inquiring into this subject, made the following experiments.

I took, says this great experimentalist, a tub about eighteen inches deep, and about two wide, and filled it with fine mould, in which I planted some beans and peas; their eyes were placed in various directions, and over the surface was spread a close meshed net. The mouth of this tub was turned down, being raised about three feet from the ground, and was suspended between two posts. Round the tub, and over its bottom, which was uppermost, were placed wet straw, mats, &c. to take off any influence the sun or air might have upon its contents, and a small hole was bored in its bottom, to which was fixed a small long tube that came through the straw. This was intended for pouring some water, if I found the earth get dry, into the tub. Under the mouth of the tub I placed *looking-glasses*, in such a way that the light was thrown upon the mouth of the tub, or surface of the earth. The weather was fine, so that through the whole day there was the reflection of the looking glasses upon the surface of the mould, which was much more powerful than day-light without the direct rays of the sun. This I continued till I conceived that the beans and peas had

grown some length, but not finding their tops coming down through the surface of the mould, I examined the contents of the tub, and found that they had all grown upwards towards the bottom of the tub, and that in those whose eyes had been placed downwards the young shoot had turned round so as to rise up. As one experiment leads to another, I wished to see how a bean would grow if kept in a constant rotatory motion. For this purpose I put some earth in a basket, having the shape of a cylinder, and about a foot diameter, with the two ends of wood for greater strength, through the centre of which I fixed an axis or spindle; in this earth I planted a bean, about half way between the surface and axis, with its eye to the surface. The basket was laid across the mouth of a large tub, with the ends of the spindle resting on the edges of the tub, which were fitted to one another so as to allow of easy motion. Round the basket was rolled some small cord, to the end of which was suspended a box, water tight; into this was put lead, so as almost to make it sink in water, and which was sufficient to turn the basket round in the open air. This large tub was filled with water, and the box placed upon it, and the spindle with the basket placed across the mouth of the tub; a very small hole was bored at the lower end of the tub, which allowed the water to escape, but very slowly; as the water sunk in the tub the box descended, and as the box descended the basket turned round. This tub took about twelve hours in emptying, and during that time the spindle with the basket only turned about once and a half. The tub was repeatedly filled, and when I conceived the bean might have grown some inches, if it had grown at all, I examined it, and found it had grown as much as if it had been planted in the common ground, but it had no particular direction but that of passing in a straight line from the bean, which was at first towards the circumference, the direction in which it was planted; but in its course it had met with a small stone, which had turned it into the direction of the axis, and it had gone on in a straight line in that direction. Here, as there was no fixed inducement to grow in any one direction, the bean grew in a straight line in that direction given it by chance.

The ingenious Mr. Knight performed the following experiments to elucidate this mysterious subject.

Having a strong rill of water passing through my garden, I constructed a small wheel similar to those used for grinding corn, adapting another wheel of a different construction, and formed of very slender pieces of wood,

to the same axis. Round the circumference of the latter, which was eleven inches in diameter, numerous seeds of the garden bean, which had been soaked in water to produce their greatest degree of expansion, were bound, at short distances from each other. The radicles of these seeds were made to point in every direction; some towards the centre of the wheel, and others in the opposite direction; others as tangents to its curve, some pointing backwards, and others forwards, relative to its motion; and others pointing in opposite directions in lines parallel with the axis of the wheels. The whole was inclosed in a box, and secured by a lock, and a wire grate was placed to prevent the ingress of any body capable of impeding the motion of the wheels.

The water being then admitted, the wheels performed something more than 150 revolutions in a minute; and the position of the seeds relative to the earth was of course as often perfectly inverted, within the same period of time; by which I conceive that the influence of gravitation must have been wholly suspended.

In a few days the seeds began to germinate, and as the truth of some of the opinions I had communicated to you, and of many others which I had long entertained, depended on the result of the experiment, I watched its progress with some anxiety, though not with much apprehension; and I had soon the pleasure to see that the radicles, in whatever direction they were protruded from the position of the seed, turned their points outwards from the circumference of the wheel, and in their subsequent growth receded nearly at right angles from its axis. The plumes, on the contrary, took the opposite direction, and in a few days their points all met in the centre of the wheel. Three of these plants were suffered to remain on the wheel, and were secured to its spokes to prevent their being shaken off by its motion. The stems of these plants soon extended beyond the centre of the wheel: but the same cause, which first occasioned them to approach its axis, still operating, their points returned and met again at its centre.

The motion of the wheel being in this experiment vertical, the radicle and plume of every seed occupied, during a minute portion of time in each revolution, precisely the same position they would have assumed had the seeds vegetated at rest; and as gravitation and centrifugal force also acted in lines parallel with the vertical motion and surface of the wheel, I conceived that some slight objections might be urged against the conclusions I felt inclined to draw. I therefore added to the machinery I have described

another wheel, which moved horizontally over the vertical wheels; and to this, by means of multiplying wheels of different powers, I was enabled to give many different degrees of velocity. Round the circumference of the horizontal wheel, whose diameter was also eleven inches, seeds of the bean were bound as in the experiment which I have already described, and it was then made to perform 250 revolutions in a minute. By the rapid motion of the water-wheel much water was thrown upwards on the horizontal wheel, part of which supplied the seeds upon it with moisture, and the remainder was dispersed, in a light and constant shower, over the seeds in the vertical wheel, and on others placed to vegetate at rest in different parts of the box.

Every seed on the horizontal wheel, though moving with great rapidity, necessarily retained the same position relative to the attraction of the earth; and therefore the operation of gravitation could not be suspended, though it might be counteracted, in a very considerable degree, by centrifugal force: and the difference I had anticipated between the effects of rapid vertical and horizontal motion, soon became sufficiently obvious. The radicles pointed downwards about ten degrees below, and the plumes as many degrees above the horizontal line of the wheel's motion; centrifugal force having made both to differ 80 degrees from the perpendicular direction each would have taken, had it vegetated at rest. Gradually diminishing the rapidity of the motion of the horizontal wheel, the radicle descended more perpendicularly, and the plumes grew more upright; and when it did not perform more than 80 revolutions in a minute, the radicle pointed about 45 degrees below, and the plume as much above the horizontal line; the one always receding from, and the other approaching to, the axis of the wheel.

I would not, however, be understood to assert that the velocity of 250, or of 80 horizontal revolutions in a minute, will always give accurately the degrees of depression and elevation of the radicle and plume which I have mentioned; for the rapidity of the motion of my wheels was sometimes diminished by the collection of fibres of conferva against the wire grate; which obstructed in some degree the passage of the water: and the machinery, having been the workmanship of myself and my gardener, cannot be supposed to have moved with all the regularity it might have done, had it been made by a professional mechanic. But I conceive myself to have fully proved that the radicles of germinating seeds are made to descend, and

their plumes to ascend, by some external cause, and not by any power inherent in vegetable life: and I see little reason to doubt that gravitation is the principal, if not the only agent employed, in this case, by nature. I shall therefore endeavour to point out the means by which I conceive the same agent may produce effects so diametrically opposite to each other.

The radicle of a germinating seed (as many naturalists have observed) is increased in length only by new parts successively added to its apex or point, and not at all by any general extension of parts already formed; and the new matter which is thus successively added, unquestionably descends in a fluid state from the cotyledons.* On this fluid, and on the vegetable fibres and vessels whilst soft and flexible, and whilst the matter which composes them is changing from a fluid to a solid state, gravitation, I conceive, would operate sufficiently to give an inclination downwards to the point of the radicle; and as the radicle has been proved to be obedient to centrifugal force, it can scarcely be contended that its direction would remain uninfluenced by gravitation.

I have stated that the radicle is increased in length only by parts successively added to its point: the plume, on the contrary, elongates by a general extension of its parts previously organized; and its vessels and fibres appear to extend themselves in proportion to the quantity of nutriment they receive. If the motion and consequent distribution of the true sap be influenced by gravitation, it follows, that when the plume, at its first emission, or subsequently, deviates from a perpendicular direction, the sap must accumulate on its under side: and I have found in a great variety of experiments on the seeds of the horse chesnut, the bean, and other plants, when vegetating at rest, that the vessels and fibres on the under side of the plume invariably elongate much more rapidly than those on its upper side; and thence it follows that the point of the plume must always turn upwards. And it has been proved that a similar increase of growth takes place on the external side of the plume when the sap is impelled there by centrifugal force, as it is attracted by gravitation to its under side, when the seed germinates at rest.

This increased elongation of the fibres and vessels of the under side is not confined to the plumes, nor even to the annual shoots of trees, but

* See Philosophical Transactions of 1805.

occurs and produces the most extensive effects in the subsequent growth of their trunks and branches. The immediate effect of gravitation is certainly to occasion the further depression of every branch which extends horizontally from the trunk of the tree; and, when a young tree inclines to either side, to increase that inclination: but it at the same time attracts the sap to the under side, and thus occasions an increased longitudinal extension of the substance of the new wood on that side. * The depression of the lateral branch is thus prevented; and it is even enabled to raise itself above its natural level, when the branches above it are removed; and the young tree, by the same means, becomes more upright, in direct opposition to the immediate action of gravitation: Nature, as usual, executing the most important operations by the most simple means.

I could adduce many more facts in support of the preceding deductions, but those I have stated I conceive to be sufficiently conclusive. It has, however, been objected by Du Hamel, (and the greatest deference is always due to his opinions,) that gravitation could have little influence on the direction of the plume, were it in the first instance protruded, or were it subsequently inverted, and made to point perpendicularly downwards. To enable myself to answer this objection, I made many experiments on seeds of the horse chesnut and of the bean, in the box I have already described; and as the seeds there were suspended out of the earth, I could regularly watch the progress of every effort made by the radicle and plume to change their positions. The extremity of the radicle of the bean, when made to point perpendicularly upwards, generally formed a considerable curvature within three or four hours, when the weather was warm. The plume was more sluggish; but it rarely or never failed to change its direction in the course of twenty-four hours; and all my efforts to make it grow downwards, by slightly changing its direction, were invariably abortive.

Another, and apparently a more weighty, objection to the preceding hypothesis, (if applied to the subsequent growth and forms of trees,) arises from the facts that few of their branches rise perpendicularly upwards, and that their roots always spread horizontally; but this objection I think may be readily answered.

The luxuriant shoots of trees, which abound in sap, in whatever direc-

* This effect does not appear to be produced in what are called weeping trees; the cause of which I have endeavoured to point out in a former Memoir. Phil. Trans. 1804.

tion they are first protruded, almost uniformly turn upwards, and endeavour to acquire a perpendicular direction; and to this their points will immediately return, if they are bent downwards during any period of their growth; their curvature upwards being occasioned by an increased extension of the fibres and vessels of their under sides, as in the elongated plumes of seeds. The more feeble and slender shoots of the same trees will, on the contrary, grow in almost every direction, probably because their fibres, being more dry, and their vessels less amply supplied with sap, they are less affected by gravitation. Their points, however, generally shew an inclination to turn upwards; but the operation of light, in this case, has been proved by Bonnet* to be very considerable.

The radicle tapers rapidly as it descends into the earth, and its lower part is much compressed by the greater solidity of the mould into which it penetrates. The true sap also continues to descend from the cotyledons and leaves, and occasions a continued increase of the growth of the upper parts of the radicle, and this growth is subsequently augmented by the effects of motion, when the plume has risen above the ground. The true sap is therefore necessarily obstructed in its descent; numerous lateral roots are generated, into which a portion of the descending sap enters. The substance of these roots, like that of the slender horizontal branches, is much less succulent than that of the radicle first emitted, and they are in consequence less obedient to gravitation: and therefore meeting less resistance from the superficial soil, than from that beneath it, they extend horizontally in every direction, growing with most rapidity, and producing the greatest number of ramifications, wherever they find most warmth, and a soil best adapted to nourish the tree. As these horizontal, or lateral, roots surround the base of the tree on every side, the true sap, descending down its bark, enters almost exclusively into them, and the first perpendicular root, having executed its office of securing moisture to the plant whilst it is thus deprived of proper nutriment, and, ceasing almost wholly to grow, becomes of no importance to the tree.

Thus is this dark matter attempted to be unfolded: but I do not think there is much difference between these kind of explanations and that of those writers who have ascribed the ascent of the plumule and the descent of the

---

* Récherches sur l'Usage des Feuilles dans les Plantes.

radicle to "a mysterious instinct," or to "a kind of fore-knowledge." The time may possibly arrive, when these movements of the plume and radicle in its germinating state, will be deemed instances of instinct* as much as the first movements of certain species of birds when they have escaped from their egg; as much so as the instinct which impels the duckling to seek the water, or the chick of the *American Pheasant* (TETRAO CUPIDO) to seek the wood, even when neither of them have been hatched under females of their own kind.

The instinct of certain animals is truly wonderful; and to solve this problem recourse has been had by Des Cartes, and by other philosophers, to conformation of body, and mechanical impulse. Their reasonings, however, though often ingenious, involve the subject in tenfold obscurity. We can hardly suppose that the animals actually foresee what is to happen, because, at first, they have not had even the aid of experience; and, particularly in some of the insect tribes, the parents are dead before their young are produced. Pure instincts, of this kind, therefore, must be referred to another source. In a chain of reasoning concerning the operations of Nature, such is the constitution of our minds, that we are under the necessity of resorting to an Ultimate Cause: the essence of that cause, it is the highest presumption in man to pretend to divine; but though we must for ever remain ignorant of the cause, we are enabled to trace, and even to understand, partially, some of the effects; and from these effects we perceive the most consummate wisdom, the most elegant and perfect contrivances to accomplish the multifarious and wonderful intentions of Nature. In contemplating the operations of animals from man down to the seemingly most contemptible insect, or even vegetables, we are necessarily compelled to refer them to pure instincts or original qualities of seeming thought, diversified by Nature according as the necessities, preservation, and continuation of the different species may require.

---

* Vide Sect. in Vol. II. on the "Perceptivity of Plants."

SECT. XXV.

APPENDAGES TO CERTAIN SEEDS.

NATURE with Art supreme maintains her race,
Some seeds with wings adorns to fly in air;
Others SHE arms with hooks, a vagrant tribe!
And these, like dust, are wafted by each breeze.

BOYD.

THE APPENDAGES to seeds, or CORONULA, are, I. The PAPPUS, or *Crown*. II. The COMA, or *Tuft*. III. The PUBES, or *Down*. IV. The CAUDA, or *Tail*. V. The ROSTRUM, or *Beak*. VI. The ALA, or *Wing*. VII. The CRISTA, or *Crest*. And VIII. The HAMA, or *Hook*.

I. The PAPPUS, or *Crown*, is commonly translated *down*, or *wool*, but this is botanically expressed by the terms *lanugo* and *tomentum*, the *woollyness*, or soft short hairs on the surface of leaves. It is termed by the French *aigrette*. Linnæus defines the *Pappus* to be "a feathery, or hairy crown, adapted for flying." Gærtner, with great propriety, restrains this part to that feathery, chaffy, or bristly down, of those seeds which have *no pericarp*, and which originate from a partial calyx, crowning the summit of the seeds, remaining after the corolla, &c. are fallen.

The PAPPUS is either *sessile* or *stipitate*.

1. The *Sessile Crown* is where the down is affixed directly upon the seed itself.
2. The *Stipitate Crown*, where the down is attached to the seed by the intervention of a *stipe*, or *thread*, (STIPES).

Instances of this feathery appendage are in the *Thistle* (CARDUUS), whose *crown* is *sessile*; and in the seeds of the *Dandelion* (LEONTODON) and *Goat's-beard* (TRAGOPOGON), whose *crown* is *stipitate*. But in the *Succory* (CICHORIUM), it consists of mere chaffy teeth, which evinces its affinity with the calyx. In the *Scabious* (SCABIOSA), it is double. In the *Bur-marygold* (BIDENS), it is formed of two, three, or four-barbed bristles.

II. The Coma, or *Tuft,* is very nearly allied to *Pappus,* and by the generality of botanists confounded with it. Gærtner first made the distinction, and judiciously discriminates it from the pappus, as being the *feathery crown* of seeds contained within a *capsule,* as the *Willow-herb* (Epilobium).

III. The Pubes, or *Down,* is a soft appendage or woolliness attached to the base or side of seeds, as the *Willow* (Salix), *Cotton-grass* (Eriophorum), *Cotton-plant* (Gossipium).

IV. The Cauda, or *Tail,* is an elongated, generally feathery appendage to some *seeds,* formed from the permanent style; or in other words, a slender process, or thread, terminating a *seed, hirsute,* from the base to the apex. The *Cauda* is much longer than the seed itself, as in *Virgin's Bower* (Clematis), and in the *Pasque Flower* (Anemone Pulsatilla).

V. The Rostrum, or *Beak,* is an elongation also of the style, which is permanent, but affixed to the *pericarp,* as in the *Geranium.*

VI. The Ala, or *Wing,* is a dilated membraneous appendage affixed to some seeds. In such seeds the *wing* is commonly solitary, except in some umbelliferous plants, as in the *Thapsia.*

When it occupies the top and back, it is especially denominated a *Wing* (Ala); but when it surrounds the sides, a *Margin* (Margo).

Pericarps as well as *seeds* are also furnished with Alæ, *Wings,* hence the botanical terms

One-winged (Monopterygia), possessing one wing only, as the *Ash* (Fraxinus). *Two-winged* (Dipterygia), as the *Maple* (Acer). *Three-winged* (Tripterygia), as the *Begonia. Four-winged* (Tetraptera), as the Halesia Tetraptera, *Four-winged Halesia. Five-winged* (Pentaptera) *Guaicum. Many-winged* (Polyptera), *Crown Imperial* (Fritillaria). *A membraneous Margin* (Margo Membranaceus), as in *Shepherd's Purse* (Thlaspi Bursa Pastoris), and *Penny-wort,* (Hydrocotyle.)

VII. The Crista, or *Crest,* is very nearly allied to the wing, but it is narrower, less flexible, and formed of a coriaceous or cork-like matter, and always placed at the back of fruits.

VIII. The Hama, or *Hook,* is a hooked projection arising from seeds or pericarps, which attaches itself to passing bodies, as in the *Burdock* (Arctium Lappa).

SECT. XXVI.

DISSEMINATION OF SEEDS.

So on the shoreless air th' intrepid Gaul
Launch'd the vast concave of his buoyant ball.
Journeying on high, the silken castle glides
Bright as a meteor through the azure tides;
O'er towns, and towers, and temples wings its way;
Or mounts sublime, and gilds the vault of day.
Silent, with up-turn'd eyes, un-breathing crowds
Pursue the floating wonder to the clouds;
And, flush'd with transport, or benumb'd with fear,
Watch, as it rises, the diminish'd sphere.
Now less and less!—and now a speck is seen!
And now a fleeting rock obtrudes between.
With bended knees, rais'd arms, and suppliant brow,
To every shrine with mingled cries they vow.
"Save him, ye saints! who o'er the good preside:
"Bear him, ye winds! ye stars benignant, guide!"
The calm philosopher in ether sails,
Views broader stars, and breathes in purer gales;
Sees, like a map, in many a waving line,
Round Earth's blue plains her lucid waters shine;
Sees at his feet the forky lightning glow,
And hears innocuous thunder roar below.

Darwin.

The wisdom of God in the universe has been copiously treated of by a variety of learned and sensible writers, particularly Ray, Durham, and Paley. The contemplative and curious inquirer will, however, find abundant matter to add to the observations of these learned and pious men. Among other parts of this infinite wisdom we cannot fail to admire the manner by which the earth is covered with vegetables.

The fertility of nature in the production of seeds is almost incredible, and which serves to repair those unavoidable losses which are so great as to seem to threaten the total extinction of several vegetable families, or genera. A single stalk of *Indian Corn* (Zea Mays) produced in a single summer 2000 seeds; in the same period a plant of *Elecampane* (Helenium) produced 3000 seeds; the *Common Sun-flower* (Helianthus Annuus) 4000; the *Poppy* (Papaver) 32,000: a single capsule of the *Tobacco* was

found to contain 1000, and one of the *White Poppy* 3000 seeds. Each capsule of the *Vanilla* contains from 10,000 to 15,000 seeds!

Ray informs us, from actual experiment made by himself, that 1012 tobacco-seeds are equal in weight to one grain; and that the weight of the whole quantity of seed in a single stalk of *tobacco*, is such, that the number of seeds, according to the above-mentioned proportion, must be 360,000!

The same learned naturalist justly computes that the annual produce of a single stalk of the *Spleen-wort* (Asplenium) to be upwards of *one million* of seeds!

Du Hamel relates that a single grain of *barley* produced in 1720, 154 spikes, which together contained 3300 grains, which being sown the following year, produced rather more than a bushel; and this being sown, produced in 1722, 45 other bushels and a quarter. In another instance a single grain of *barley* produced 200 spikes, and these contained 4800 grains, and the next year these last would have produced 23,040,000; and the product of the third year would have been 110,592,000,009; and the fourth year beyond the bounds of calculation.

Dr. Woodward has calculated that a single thistle-seed will produce at the first crop 24,000 seeds; and consequently, *five hundred and seventy-six millions* of seeds at the second crop!

Well then might Virgil sing,

> Mox et frumentis labor additus: ut mala culmos
> Esset rubigo; segnisque horreret in arvis
> *Carduus*; intereunt segetes; subit aspera sylva,
> Lappæque, tribulique Georg. Lib. I.

In order to secure the existence of plants, nature hath contrived various modes of dispersing abroad the seeds, which, as they find a soil adapted for their state, either take root and establish themselves, or perish, to become manure for other vegetables.

The modes of dissemination are extremely various, as,

I. *By a peculiar elastic spring in the pericarp, or seed-vessel.*

II. *The appendages attached to seeds.*

III. *From seas, rivers, and brooks.*

IV. *Birds, and other animals.*

I. Many seeds are dispersed to a considerable distance by means of an *elastic force* which resides in some part of the fructification. This is very

conspicuous, as was mentioned before, in the *Wood Sorrel* (Oxalis Corniculata), and the *Wild Cucumber* (Momordica); but more particularly in our common garden *Balsam*, whose pericarp consists of five valves so united as to appear one homogeneous body, but when touched (hence the *balsam* is called Noli me tangere) some, or all of these divisions, suddenly fold back into a spiral form, and ejaculate the seeds to a considerable distance. The same may be said of the *Spurge* (Euphorbia), *Dittany* (Dictamnus), and Phyllanthus. Several seed-vessels burst with an explosive force, and throw the seeds to a distance, says Lord Kames, in the Gentleman Farmer, and this is the case with our *Whin* (Ulex) Furze; for did the seeds fall perpendicularly down, they would be suffocated in the heart of an impenetrable bush. On a clear summer's day, says Dr. Smith, they produce an agreeable crackling noise. But the most remarkable instance is the *Sand-box tree* (Hura Crepitans), whose ripened pericarps explode in a bright sun-shine every five or ten minutes with the noise of a pistol.

The seeds of the *Hart's-tongue* (Asplenium) are shot out by a very artful contrivance. The capsule is an hollow ball, nearly surrounded by an elastic ring, which, like a bow, is stretched to its highest pitch of elasticity, when it shoots back, separating the ball into two hemispheres, thus ejaculating the seeds.

If a moderate quantity of the minute capsules of *Fern* (Filix), says Ray, be shaken upon a sheet of white paper and gathered into a heap, by these starting asunder and striking each other, the whole heap will appear to be in motion in several parts, as if filled with small live insects; and if the place be still, by approaching the ear to the heap, one may hear the sound of the little vesicles crackling as they burst, and observe the seeds flying off, scattered to a considerable distance from the heap.

The pericarp of the *Geranium*, and the arista, or beard of the *Wild Oat* (Avena Fatua), are twisted, doubtless, for a similar purpose, and, being extremely sensible to the changes of the atmosphere, readily dislodge their seeds on wet days, when the earth is best fitted to receive them. The *former* of these has a kind of feathery leg, which occasions it be rolled along by the least breath of air; or it may elongate and contract, like the *walking oat*, and thus creep along the ground. *

The *Rose of Jericho* (Anastatica), is equally curious, and well known.

* The awns of the *Geranium* have been used as *hygrometers* by striking the base of the seed into a cork for a pedestal, and marking divisions on a paper circle beneath it. The *awn* of the

II. The *Pappus,* or *Down,* attached to some kind of seeds, gives them the exact appearance of shuttle-cocks, and forms them for an aerial flight, being an admirable contrivance of Nature to disseminate her productions, and thus render common to different territories, individuals of the same species, which, without such precaution, might have been confined to one. The *pappus* is, indeed, one of the most wonderful contrivances employed by the liberal hand of Nature for distributing her vegetable productions over the surface of the globe. There can be little doubt but that many species of plants, particularly among the *compound* flowers, owing to their being supplied with the *pappus,* have extended themselves over countries where they were not the original natives. Thus about an hundred years ago the *Canadian Fleabane* (ERIGERON CANADENSE) was introduced from Canada into the botanic garden at Paris, and it is now found spread over France, Holland, Germany, and Italy.

Thus the seeds of the *Thistle* (CARDUUS), *Blue-bottle* (CENTAUREA), *Dandelion* (LEONTODON), *Succory* (CICHORIUM), and *Groundsel* (SENECIO), being furnished with pinions, plumes, or tufts, are conveyed to a prodigious distance, and hence appear to have a true locomotive power.

Some of these pinions are actually *barbed,* as in the *Feather-grass* (STIPA), where the *awn* (ARISTA) is from six to twelve inches in length, or even more, nodding, angular, twisted at the base, and clothed almost the whole length with very fine white pellucid *divergent hairs,* which at first occasion the seeds of this grass to be carried to a distance by the wind; and when these have acquired their hold in any place, being actually screwed into the earth by the twirling of the *arista,* the *pennæ,* or *wings,* break off, and leave behind the imbedded seed.

There is not a single vegetable, remarks the benevolent JAMES HENRY BERNARDIN DE SAINT PIERRE, in his Studies of Nature, the leaf of which is disposed to receive the rain-water on the mountains, whose seed is not formed in a manner the best adapted to raise itself thither. The seeds of

---

barley is furnished with stiff points, which, like the teeth of a saw, are all turned towards one end of it; as this long awn lies upon the ground, it extends itself in the moist air of night, and pushes forwards the *barley-corn,* which it adheres to; in the day it shortens as it dries; and as these points prevent it from receding, it draws up its pointed end, and thus, creeping like a worm, will travel many feet from the parent stem; and may thus be used as a travelling *hygrometer,* when laid on a cloth on the floor, like the *automaton* of Mr. Edgeworth, described in the Botanic Garden by Dr. Darwin.

all mountain plants are *volatile.* By inspecting their leaves it is possible to ascertain the character of their seeds, and by inspecting the seeds to discover that of their leaves, and thence to infer the elementary character of the plant. By mountain plants I here mean all those which grow in sandy and parched situations, on eminences, on rocks, on steep ridges by the road side, in one word, at a distance from water.

Hence it is that the seeds of the *Maple* (Acer) have two membraneous pinions, similar to the wings of a fly. Those of the *Elm* (Ulmus) are inclosed in the middle of an oval thin leaf. Those of the *Cedar* (Pinus Cedrus) are terminated by broad thin plates, which in their aggregate state compose a cone, and when arrived at maturity, the thin membranes to which they adhere, which line the woody scales, separate from each other, and, with the seeds in the centre, thus winged, fly away to some distant part.

It is highly worthy of remark, that *volatile* seeds are produced in much greater number than those of any other kind; and in this respect we have reason to admire the wisdom of that Providence which foresaw every thing, and arranged the whole accordingly. The elevated spots for which they are destined, were exposed to be speedily stripped of their vegetables by the declivity of their situation, and by the rains, which have a continual tendency to render them lower; but by means of the *volatility* of certain seeds, they are become, of all the places on the earth, the most abundant in plants.

Finally, we must observe, and not without profound admiration, that the season of the maturity of most *volatile* seeds takes place towards the commencement of autumn, and that, in consequence of the universal intelligence which constrains all the parts of Nature to act in concert, the most violent gales of wind,* called the equinoxial winds, blow then, towards the end of September, or beginning of October.

Thomson, who has been called with great propriety, "*Nature's Poet,*" has so beautifully, and at the same time so philosophically alluded to the dispersion of seeds, that I cannot close this paragraph without inserting his beautiful lines on that subject.

> ———————— A fresher gale
> Begins to wave the wood, and stir the stream,
> Sweeping with shadowy gusts the fields of corn;

---

* Vide our English Calendar. Sect. XIII. p. 69.

While the quail clamours for his running mate.
Wide o'er the *thistly* lawn, as swells the breeze,
A whit'ning shower of vegetable *down*
Amusive floats. The kind impartial care
Of NATURE, nought disdains: thoughtful to feed
Her lowest sons, and clothe the coming year,
From field to field the *feather'd seeds* SHE *wings*.
THOMSON'S SUMMER, l. 1635.

The generality of seeds are so small as to rise like dust before the wind; and for this purpose the stalks and stems rise in the air, and their leaves, catching the gale, tend the more to their dispersion.

III. *Aquatic Expeditions.* There is to be found in Nature, a link which connects the *volatile* and *aquatic* seeds. Thus the *Willow-herb* (EPILOBIUM), which grows on the banks of ponds, and in humid situations, has its seeds clothed with down, so as to be wafted by the winds, or sail upon the water. Thus the *Willow* (SALIX) has its seeds surrounded by a cobweb of down, rendering it capable of being transported to a great distance by the wind, but which, like the feathers of a duck, float on the surface of the water, until they reach a convenient shore. The same is the case with the *Poplar* (POPULUS). The *Fir* (PINUS) and *Birch* (BETULA) also possess the *volatile* and *nautical* character. As these trees grow on the sides of bleak and wintry mountains, and on the borders of vast lakes, their seeds have not only to sail over stagnant waters, but to be transported through the air over the snow, in which they delight to grow. As the examination of so many curious circumstances would carry us too far, I shall only mention the *Linden tree* (TILIA), the seeds of which are enclosed in a spherical body, similar to a small bullet: this bullet is affixed to a long tail, from whose extremity descends a follicle of considerable length, in an oblique direction, by which the wind carries it to a great distance, spinning it round and round. When it drops into the water it plunges about the depth of an inch, and serves, in some sort, as ballast to its tail, and to the small leaf attached to it, which being thus brought to a vertical position, perform the functions of a mast and sail.

The *seeds* of *aquatic plants* have forms no less adapted than those of their leaves to the places where they are destined to grow; they are all constructed in a manner most proper for sailing. These are formed, many of them, like regular constructed boats, rafts, or skiffs, as well as single and double canoes, similar to those of the South Seas. I have no doubt, says SAINT PIERRE, that by attentive study of this part alone, a great number

of very curious discoveries might be made respecting the art of crossing currents of every sort; and I am persuaded, that the first men, who were much better observers than we are, took their different methods of voyaging from those models of Nature, of which, with all our pretensions to discovery, we are but feeble imitators. The MARTYNIA is a complete Venetian barge.

The *maritime Pine* (PINUS PINASTER) has its kernels inclosed in a kind of small bony shell, notched on the lower side, and covered on the upper with a piece resembling a ship's hatch. The *Walnut* (JUGLANS), which delights so much on the banks of rivers, has its fruit contained in two small boats, fitted to each other. The *Hazel* (CORYLUS), which becomes so bushy on the brink of rivulets, and the *Olive* (OLEA), which loves the sea-shore to such a degree that it degenerates in proportion as it is removed from it, bear their seeds inclosed in a species of small casks, capable of enduring the longest voyages. The red berry of the *Yew* (TAXUS), whose favourite residence is the cold and humid mountains, near the margin of lakes, is hollowed out into a little bell. This berry, on dropping from the tree, is at first carried down by its fall to the bottom of the water, but it instantly returns to the surface by means of a hole, which nature has contrived, in the form of a navel, above the seed. In this aperture is lodged a bubble of air, which brings it back to the surface of the water, by a mechanism more ingenious than that of the diving-bell, as the vacuum of the latter is undermost, and that in the berry of the yew uppermost.

The forms of the seeds of aquatic plants are still more curious; for Nature every where redoubles her skill and exertions in favour of the small and the weak. Those of the *Fennel* (ANETHUM), are real canoes in miniature, hollowed out in the middle, with both ends raised into a prow. There are others grooved into each other, like pieces of wood disposed for a float, as those of the *horned Poppy* (CHELIDONIUM). Those destined to thrive on the brink of water, are wafted by sails, as is the case with the seeds of a *Scabious* (SCABIOSA MARITIMA) of our own country, which grows on the sea-shore. Beside this difference from all the other species of Scabious, whose seeds are crowned with hooked hairs, in order that they may adhere to the hair of animals, which transplant them, the one last mentioned is overtopped by an open half bladder, which rests on its summit like a gondola. This half bladder serves it at once as a sail by water, and as a vehicle by land. These means of natation, though varied without end, are, in all climates, common to the seeds of aquatic plants.

The *Almond* of the river of the Amazons, known by the name of *Totoca,* is inclosed in two shells, exactly similar to those of our oyster. Another fruit growing on the banks of the same river, which abounds in almond trees, has a perfect resemblance, in colour and form, to an earthen pot with a small lid;* it goes by the name of the *Monkey's Porridge Pot.* Others are formed into large bottles, as the fruit of the large *Gourd.* Some are inclosed in a coat of wax, which makes them float; such are the berries of the *Wax Tree,* or *Royal Pimenta,* found on the shores of Louisiana. The formidable apple of the *Manchineel,* which grows on the sea coast of the islands situated between the tropics, and the fruit of the *Mangrove,* which actually grows there in the salt water, are almost ligneous. There are others with shells, similar to the sea-urchin, without prickles. Many are coupled, and perform their voyage like the double canoe, or balse, of the South Sea. Such is the *double Cocoa* of the Sechelles Islands.

If we examine the leaves, the stems, the attitudes, and the seeds of aquatic plants, we shall observe in them characters which have a relation to the places where they are destined to grow, and in harmony with each other; so that if the seed has a nautical form, its leaves are deprived of an aqueduct; just as in mountain plants, if the seed is volatile, the peduncle of the leaf, or the leaf altogether, represents a channel.

I shall assume, as an instance of the nautical harmonies of plants, the *Nasturtium,* with which every one is acquainted. This plant, which bears flowers so agreeable, is one of the cresses found near the rivulets of Peru. It must be observed first that the foot-stalks of its leaves have no conduit, like those of all aquatic plants; they are inserted in the middle of the leaf, which they support like an umbrella, to shelter them from the water that falls from the heavens. Its *seed,* when fresh, has exactly the form of a boat. The upper part, which is raised, slopes like a bridge, to let the water run off; and one may clearly distinguish in the lower part, a poop and a prow, a keel and a bottom. (*See the annexed Plate.*) The small furrows of the seed of the Nasturtium are characterizing marks, common to most nautical seeds, as well as the triangular forms, and those of the kidney or keel. These furrows undoubtedly prevent them from rolling about in all directions, constrain them to float along lengthwise, and give them that direction best adapted to the course of the water, and for passing through the nar-

---

* See engravings of most of those seeds in John de Laet's "History of the West Indies."

rowest straits. But they have a character still more general: they swim in their state of maturity, which is not the case with seeds destined to grow on the plains, such as pease and lentils, which sink to the bottom. Some species of these, however, such as the French bean, sink, at first, to the bottom, and rise to the surface when penetrated with water. Others, on the contrary, float at first, and sink afterwards: such is the *Egyptian Bean* (NYMPHÆA NELUMBO), which grows in the waters of the Nile. In order to sow it, you are under the necessity of rolling it up in a ball of earth, and in that state it is thrown into the water. Without this precaution, not one would remain on the shores where you wish it to grow.*

The natability of aquatic seeds is undoubtedly proportioned to the length of the voyages which they have to perform, and to the different gravity of the waters in which they are destined to swim. There are some that float in sea water, and sink in fresh, which is lighter than sea water by one thirty-second part: such is the precision of Nature in adjusting the weight of bodies to each other! This is the case, I believe, with the fruit of the *Indian Chestnut* (ÆSCULUS PAVIA), which thrives on the shores of the salt creeks of Virginia. In a word, I am so fully convinced of all the relations which Nature has established between her works, adds ST. PIERRE, that I am persuaded the time when the seeds of aquatic plants drop, is regulated, in most cases, by that of the overflowing of the rivers near which they grow.

It is a speculation highly worthy of the philosophic mind, to trace those vegetable fleets sailing along streams night and day, and arriving, undirected by any pilot, on unknown regions. There are some which, by the overflowing of the waters, now and then, lose themselves in the plains. I have seen them sometimes accumulated in the beds of torrents, presenting, around the pebbles where they had germinated, waves of verdure of the most beautiful sea-green. Others, more fortunate, issuing from the sources of some rivulet, are caught by the current of the large rivers, and carried away to embellish their distant banks with a verdure not their own.

There are some which cross the vast ocean; and, after a long navigation, are driven, by the very tempests, to the shores, which they adorn and en-

---

* What is very remarkable in this seed, is, that it vegetates in a receptacle, and expands its lobes before it quits its parent plant, and in that state is wafted by the waters to some distant shore. Vide our superb Plate of the Nelumbium, in the 'New Illustration of the Sexual System.'

rich: such are the *Double Cocoas* of the Sechelles, or Mahé Islands, which the sea carries regularly every year to the distance of four hundred leagues, and lands on the coast of Malabar. The Indians who inhabit that country, believed for a long time, that these annual presents of the ocean, were the produce of a *Cocoa Tree* that grew under its waves. They distinguished them by the name of marine cocoa nuts. They set as high a value upon them as upon ambergris; and to such a length was this extravagance carried, that many of those fruits have been sold as high as a thousand crowns a-piece. But the French having some years ago discovered the island of Mahé, which produces them, and which is situated in the fiftieth degree of south latitude, imported them in such quantities to India, that they sunk at once in value as well as reputation; for men, in every country, prize those things only which are rare and uncommon.

In every island where the eye of the traveller has been able to contemplate the primordial dispositions of nature, he has found the shores covered with vegetable productions, the fruits of which possess nautical characters. James Cartier and Champlain represent the borders of the lakes of North America, as shaded by stately *Walnut trees*. Homer, who studied Nature so attentively in a happy climate, and at a period when she still retained her virgin beauty, has planted the *Wild Olive* along the shores of the island on which Ulysses, floating upon a raft, is thrown by the tempest. The navigators who made the first discoveries in the seas of the East Indies, frequently found in them sand-banks planted with *Cocoa trees*. Such quantities of *Fennel Seed* are thrown by the sea on the shores of Madeira, that one of its bays has obtained the name of Funchal, or Fennel Bay.

The seeds of many vegetables are carried along by rivers, and torrents, and the ocean, and are frequently conveyed to the distance of many hundred, or thousand miles from the countries in which they were originally placed. In this manner, many of the plants of *Germany* are conveyed to the shores of the sea in *Sweden*; various plants of *Spain* and *France* are carried to the shores of *Britain*; and the plants of *Africa* and *Asia* are often conveyed to the shores of *Italy*. Sir Hans Sloane has given an account of four kinds of fruits, which are frequently thrown by the sea upon the coasts of the islands of the northern parts of Scotland. These seeds, or fruits, were *Climbing Sensitive Plant* (Mimosa Scandens), *Horse-eye Bean* (Dolichos Pruriens), *Ash-coloured Nickar tree* (Guilandina Bonduc), and the *Poison*

"*Nut*, Fructus orbicularis sulcis nervisque distinctus"* of Caspar Bauhin. All these are *American* vegetables,† and three of them were known by Sir Hans Sloane to be natives of Jamaica. These, and several other kinds of seeds, which are likewise found abundantly upon the coast of *Norway*, were thought by him to have been brought by currents, though the Gulf of Florida, into the North American ocean. Dr. Tonning has mentioned several other seeds which are actually thrown upon the coasts of *Norway*; such as those of *Cashew Nut* (ANACARDIUM OCCIDENTALE), *Bottle Gourd* (CUCURBITA LAGENARIA), *Dog-wood tree* (PISCIDIA ERYTHRINA), and *Cocoa nut* (COCOS BUTYRACEA). These are often in so recent a state, that they would unquestionably vegetate, were the climate favourable to their growth and existence. And, doubtless, they are frequently carried to countries in which they do vegetate as well as in the countries where they were originally placed by the hand of the Creator.

The philosopher, FRANCIS LEGUAT, and his unfortunate companions, who, in the year 1690, were the first inhabitants of the small island of *Rodriguez*, which lies a hundred leagues to the east of the *Isle of France*, found no *Cocoa trees* in it. But, during the period of their short residence there, the sea threw upon the coast several *Cocoa Nuts* in a state of germination, as if it had been the intention of Providence to induce them, by this useful and seasonable present, to remain on that island, and to cultivate it.

FRANCIS LEGUAT, who was unacquainted with the relations which seeds have to the element in which they are designed to grow, was very much astonished to find that those fruits, which weighed from five to six pounds, must have performed a voyage of sixty or fourscore leagues, without being corrupted. He took it for granted, and he was in the right, that they came from the island of *St. Brande*, which is situated to the north-east of *Rodriguez*. These two desert islands had not, as yet, since the creation of the world, communicated to each other all their vegetable productions, though situated in a current of the ocean, which, in the course of the year, sets six months towards the one, and six months towards the other. However this may be, he and his companions planted these *Cocoa Nuts*, which, in the space of a year and a half, sent forth shoots four feet in height.

IV. *Birds* and *animals* are no mean agents in the dissemination of

---

* Strychnos Colubrina of Linnæus.

† They are likewise natives of the East Indies.

plants. The *Cross-bill,* that lives on the *Fir-cones,* and the *Hawfinch,* that feeds on the *Pine-cones,* at the same time sow many of their seeds, especially when they carry the cone to a stone or trunk of a tree, that they may more easily strip it of its scales. The Rev. Mr. Robinson, in his Natural History of Westmoreland and Cumberland, has very particularly mentioned a thick grove of *Oak trees,* which were known to have sprung from the acorns that had been carried there by *crows* above twenty-five years ago. The *Jay* (Corvus Cristatus) is also a bird very instrumental in planting of *oaks,* being very provident in laying up stores of acorns. Rumphius assures us, that a particular species of *Pigeon* is very instrumental in disseminating the true *Nutmeg* in the East India islands.

Don Garcias de Figueroa, ambassador from Spain, at the court of Sha-Abbas, king of Persia, relates, in the account which he has given of his journey, that the lofty mountains of Persia, which he crossed, and over which the Turcomans are continually wandering, as they tend their fleecy charge, were covered with a species of thorny shrub, which grew luxuriantly in the most parched situations. These shrubs served as a retreat to a great number of *Grouse.* I shall here take occasion to observe, that Nature employs these birds particularly for the purpose of sowing thorny plants in the steepest and most inaccessible places. They are accustomed to retire thither in the night time, and there they deposit, along with their dung, the stony seeds of the *bramble berry,* the *eglantine berry,* the *barberry,* and of the berries of most thorny shrubs, which, by relations no less wonderful, are in their stomach indigestible. *

It is in this way, says Professor Barton, that the *Poke* (Phytolacca Decandra), the berries of which are eaten by the *Robin,* the *Thrush,* the *Wild Pigeon,* and many others, appear to have been so extensively diffused through North America. Many *horse-beans,* says the Rev. Gilbert White, in the 'Naturalist's Calendar,' sprang up in my field-walks in the autumn, and are now grown to a considerable height. As the *Ewel* was in beans

---

* Thavernier, in his Travels, says 'that the nutmeg is so produced.' 'There is a kind of bird in the Dutch islands, which resembles a cuckoo, and the Dutch prohibit their subjects, under pain of death, to kill any of them. They are called by the natives nut-eaters, and greedily devour as many nutmegs as their stomachs can hold, and then retire from the spot, and, feeling indigestion from the quantity, vomit them up, at different times, being warmed in the stomach, and besmeared with slime, when they never fail to take root, and produce a tree; and it is reported that none grow except they be first served in this manner.' Vide Sir Thomas Blount's Nat. Hist.

last summer, it is most likely that these beans came from thence; but then the distance is too considerable for them to have been conveyed by mice: it is most probable, therefore, that they were brought by *birds*, and in particular by *Jays* and *Pies*, who seem to have hid them among the grass and moss, and then to have forgotten where they had stowed them. Some *Peas* are also growing in the same situation, and probably under the same circumstances.

In this way it is well known that the berry of the *Mistletoe* (Viscum Album) is carried by the *Thrush*, and its glutinous substance is broken by the beak of the bird against the crab, apple, white-thorn, or other tree; and its seeds, adhering to the bark, take root in the very bosom of the tree, whence it derives its nourishment. Hence the proverb, " that the *Thrush** sows its own destruction."

It cannot be doubted, says Dr. Biberg, but that the greater part of the *Junipers* that fill our woods are sown by *Thrushes* and other birds in the same manner as the *Mistletoe*; for the berries, being of themselves heavy, cannot be dispersed by the winds.

The very incorruptible nature of the seeds of plants, is a circumstance highly favourable to their migration. We have seen that the seeds of *Mistletoe, Loranthus, Poke* (Phytolacca), and others, vegetate very well after they have been subjected to the digestive power of birds. Nay, it is a fact, that some seeds, when carried to a distance from their native countries, have generally refused to vegetate until they have been passed through the alimentary canal of birds. In Britain, this was found to be the case with the seeds of the *Common Magnolia*, or *Beaver tree* (Magnolia Glauca). This fact will excite less surprise, when it is recollected how extremely tenacious seeds are of the vital principle; or, in other words, how difficult it is to prevent seeds from living. Thus, the late illustrious Spallanzani discovered, that there are certain kinds of seeds which do not refuse to vegetate, even after having undergone the operation of boiling in water; and Duhamel mentions an instance of seeds germinating after they had experienced, in a stove, a heat of 235 degrees by the scale of Fahrenheit.

---

* This more particularly relates to the *Missel* Thrush, who does not destroy the fruit in the gardens, like the other species of thrushes, but feeds on the berries of *Mistletoe*, and in the spring on *Ivy berries*, when they begin to ripen.

Spallanzani even found, that the seeds of mouldiness, which is a true vegetable, survive a heat infinitely greater than this.

The fruit-bearing trees seem as if destined by Nature to invite to a banquet* at the same time, as being most useful to mankind, and animals, and birds, the seeds thereof are dispersed in every direction. Thus some possess in the centre the seed safely lodged in a stone, as it is called, or hard shell, as the *cherry* and *peach*; and, to excite terror, those are often considerably pointed at both ends, as the *plum*; and the *apple* has a *core* of a *ligneous* nature around the pips, and the *pear* has its seeds defended really by an *osseous* deposit.

Physiologists have discovered, that the arillus, or husk, equally as the shell of seeds, is not acted on by the gastric fluid; † and hence, when animals in their voraciousness, without mastication, swallow some of these, they pass the intestinal tube uninjured. Hence, if a field be manured by recent dung, not completely fermented, various plants injurious to the farmer will spring up, covering the field. Hence the explanation of a vulgar error, that wheat, barley, and rye, are converted into *oats,* although such changes are contrary to all common sense; yet seeing that *oats* usually spring up where these are sown, there is a more likely solution of this phenomenon,

---

* Duhamel even thinks, that the pulpy medullary part of the fruit is of no service to the contained seeds. He thus expresses himself: " A l'égard du pepin de la poire, il tient en quelque maniere le milieu entre les vivipares et ovipares; car il s'incube dans le lieu où il a été formé; c'est-a-dire, dans l'interieur de la poire. Il y a neanmoins lieu de croire que son amande se forme sans presque tirer *aucun secour* de la poire, si ce n'est par les liqueurs qui étoient contenues dans le pepin, avant que l'amande commençât à se former; car lorsque l'amande commence à paroître, les secrétions semblent interceptée par l'endurcissement des glandes. De même, dans les fruits à noyau, l'amande ne se forme que quand la boîte ligneuse est considérablement endurcie; et dans ces sortes de fruits le vaisseau umbilical est alors presque desséché." Physique des Arbres.

† " The *husk* of the seeds of plants appears to be indigestible in its natural state; whether this arises," says the celebrated John Hunter, " from the nature of the husk itself, or from its compactness, I am not certain, but am inclined to suppose the last, as we find the cocoa, which is only a husk, to be digestible when ground to a powder, and well boiled. We know, likewise, that cuticle, horn, and bone, although animal substances, are not affected by our gastric juice, but when reduced to a jelly, that jelly is readily acted upon in the stomach; we must therefore suppose, that a certain natural degree of solidity in animal and vegetable substances, render them indigestible. This *compactness,* continues Hunter, seems to be intended to preserve, whilst under ground, the farinaceous parts of seeds, in which the embryo is placed, the husk having hence its power of resisting putrefaction." Hunter on the Animal Œconomy.

Of 25 ripe *grapes* which Spallanzani swallowed by way of experiment, 18 were voided *entire,* and of the other 7, the skins only appeared. He made the same experiment with *cherries* and *currants,* as well ripe as unripe, and by far the greater number were voided *entire.* Vide our Philosophy of Medicine, Vol. III. p. 98.

that the ground has been manured with horse-dung, or at any rate ploughed by means of horses, who feed upon oats, and some of these have passed entire with the dung of that animal.

The *chesnuts* and *acorns*, which drop around their parent plant, are transported and sown by the *wild boar*, or *domestic hog*; and the nimble *squirrel*,* with one in its mouth, or *monkey*, with its paws full as well as pouch, transport these far from their original habitations; as do also *parrots* and *other birds*, who in their flight from pursuing animals, or hawks, forget their prey, and drop them at a considerable distance from their original destination.

Animals contribute to the dispersion of seeds in still another way.

The seeds of many plants attach themselves to animals, especially quadrupeds, by means of *hooks*, *crotchets*, or *hairs*, which are either affixed to the *seeds* themselves, as in *Hounds-tongue* (Cynoglossum), *Mouse-ear* (Myosotis), *Vervain*, *Water-Hemp Agrimony* (Bidens), and many others; to their *calyx*, as in *Burdock* (Arctium Lappa), *Agrimony*, *Rhexia*, *Dock* (Rumex), *Nettle*, *Pellitory* (Parietaria), *Linnæa*, &c.; or to the *pericarp*, or *seed-vessel*, as in *Liquorice* (Glycyrrhiza), *Enchanter's Night-shade* (Circæa), *Cleavers* (Galium Aparine), *Triumfetta Bartrimia*, *Martynia*, *Pea-vines* (Hedysara, of various species), not to mention many others.

In this manner, there can be no doubt, many seeds are very extensively diffused over vast tracts of country. Thus, there are good reasons to believe, says Barton, that neither common *Hounds-tongue* (Cynoglossum Officinale), nor *Burdock*, is a native of the United States: but both of these plants, which appear to have spread in the manner we have mentioned, are now to be seen in many even of the most remote parts of the Union.

Thus it is that the face of Nature is replenished, and plants approach nearer to the animal kingdom by being as it were in some degree locomotive.

---

* "Our Indians are of opinion that *squirrels* plant all the timber in their country: indeed, it must be allowed they are very active in this way. It has been asserted by Dr. Belknap of Boston, that the *Striped Dormouse*, or *Ground Squirrel* (Sciurus Striatus), previously to depositing in the earth its winter food, takes the precaution of depriving "*each* kernel of its germ, that it may not sprout." Were this a fact, it would be a wonderful mark of instinct; but I am certain that no such mutilation, in a variety of instances, is accomplished; and that, therefore, innumerable seeds that have been planted by squirrels, may, and actually do, grow into trees, and other vegetables."

Professor Barton.

SECT. XXVII.

WHETHER THE FUTURE PLANT BE CONTAINED IN THE SEED.

Lo! on each seed, within its slender rind,
Life's golden threads in endless circles wind;
Maze within maze the lucid webs are roll'd,
And, as they burst, the living flame unfold.
The pulpy *acorn,* ere it swells, contains
The oak's vast branches in its milky veins;
Each ravel'd bud, fine film, and fibre-line,
Trac'd with nice pencil on the small design.
The young *Narcissus,* in its bulk compress'd,
Cradles a second nestling on its breast;
In whose fine arms a younger embryon lies,
Folds its thin leaves, and shuts its floret-eyes;
Grain within grain successive harvests dwell,
And boundless forests slumber in a shell!

Darwin.

Many philosophers, holding it to be incredible, that a plant, or even an animal, should be endowed with a power to produce its own likeness, have embraced an opinion that all the plants and animals that ever existed, or that ever can exist, were formed originally, not plants or animals, but embryos of those inclosed in an egg or seed, which when deposited in a proper *nidus* or *matrix,* grow up to a plant or animal, and then decay. And to account for future generations, it is held, that every embryo contains within it smaller embryos without end, like cups of different sizes cased one within another.

That every seed contains an embryo-plant, is a valuable discovery in natural history; but that there is a decreasing series of embryos within every seed, is a mere conceit, assumed without the least appearance of truth. So far is it from holding true that plants within plants subsist in a seed without end, that even the single plant it contains is there in a very imperfect state. The plume and radicle *alone* subsist in it; and the other parts are produced in the course of growing. But let us give way to the supposition of an infinite series, to see what can be made of it. Writers

stop short and leave the reader in the dark, precisely where he needs light the most. A seed is laid in earth: by what mechanical power is vegetation produced and continued during the life of the plant? And by what mechanical power does motion commence in the fœtus of an animal, and the blood circulate? When a seed happens to be inverted in the ground, with its radicle above, and its plume below, what is the mechanical power that makes them wreathe about the seed till the radicle gets into earth and the plume into air?* Unless these particulars can be accounted for mechanically, an embryo must be held a pure vision. A power must be admitted even in the smallest embryo, to expand itself into a plant or animal, where it happens upon a proper nidus. And yet the admission of that power destroys the hypothesis, root and branch. A seed thrown into the ground would rest there for ever, were it not endued with a power to begin vegetation, and to continue it. It grows into a tree: why may not that tree be endued with a power to form its own seed? If so, there is no necessity to go further back: organized atoms or embryos must vanish, because there is no use for them. Power in a tree to form its seeds, is no more extraordinary than that of sucking juices from the earth, and converting them into its own substance, a power that every plant is admitted to have.

This subject has been long ago debated, and you may see in the life of Malpighi, a dispute betwixt him and Signor Triumphetti, the provost of the garden at Rome, whether the whole plant be actually contained in the seed.

Malpighi maintains, " all organized bodies pass through successive changes. Plants, of course, are not exempted from mutation. What an amazing difference between an acorn and a stately oak! The seeds of plants may be compared to the chrysalis of butterflies. The seed, like the chrysalis, contains, in miniature, all the parts of the future plant. These parts require only time, and other circumstances necessary to vegetation, for their complete evolution. How different are the seed-leaves from those of the plume! Beside the general changes arising from growth, plants undergo a number of metamorphoses from other causes. In northern climates, if we

* To ascend and descend is not the ultimate view in these two parts, but to get into the air and earth. As seeds are generally deposited on or near the surface of the ground, the plume ascends, and the radicle descends. But place a seed in an inverted flower-pot with earth in it, the radicle ascends, and the plume descends: the first pursues its road into the earth, and the other into the air.

except a few evergreens, trees, during winter, are entirely stripped of their leaves. Instead of the pleasant emotions excited by the variety of figures, movements, colours, and fragrance of the leaves, flowers, and fruit, during the spring and summer, nothing is exhibited in winter but the bare stems and branches. In this state, the trees of the forest have a lugubrious appearance, and remind us of death and of skeletons. Very different are the emotions we feel in the spring, when the buds begin to burst, and the leaves to expand. When summer approaches, another beautiful change takes place. The flowers, with all their splendour of colours, and sweetness of flavours, are then highly delightful to our senses. After performing the office of cherishing and protecting the tender fruit for some time, the flowers drop off, and a new change is exhibited. When the flowers fall, the young fruits appear, and gradually grow to maturity, perpetually presenting varieties in their magnitude, colour, odour, and flavour. When the fruit or seeds are fully ripe, they are gathered for the use of man, drop down upon the earth, or are devoured by birds and other animals. After this change happens, to which all the others were only preparatory, the leaves begin to shed, winter commences, and the same series of metamorphoses go on during the existence of the plant."

"By some the metamorphosis of insects has been regarded as a sudden operation, because they often burst their shell or silky covering quickly, and immediately appear furnished with wings. But, by more attentive observation, it has been discovered that the transformation of caterpillars is a gradual process from the moment the animals are hatched till they arrive at a state of perfection. Why, it may be asked, do caterpillars so frequently cast their skins? The new skin, and other organs, were lodged under the old ones, as in so many tubes or cases, and the animal retires from these cases, because they have become too strait. The reality of these incasements has been demonstrated by a simple experiment. When about to moult or cast its skin, if the foremost legs of a caterpillar are cut off, the animal comes out of the old skin deprived of these legs. From this fact, Reaumur conjectured, that the chrysalis might be thus incased, and concealed under the last skin of the caterpillar. He discovered that the chrysalis, or rather the butterfly itself, was inclosed in the body of the caterpillar. The proboscis, the antennæ, the limbs, and the wings, of the fly are so nicely folded up, that they occupy a small space only under the two first rings of the caterpillar. In the first six limbs of the caterpillar are incased the six limbs of

the butterfly. Even the eggs of the butterfly have been discovered in the caterpillar long before its transformation."

MALPIGHI goes on to declare, " that by the help of the microscope, he did actually observe, in the seed of a kidney-bean, the broad leaves, the buds, and even the knots, or insertions of the various stems. He perceived the stalk distinguished by its woody fibres, and the rows of its vesicles."

So LEWENHOECK, after his nice observation of an orange-kernel, which he made to germinate in his pocket, concludes, " Thus we see, how small a particle, as the plant appears, no bigger than a small dust of sand, is increased, a plain demonstration that the plant, and all belonging to it, was actually in the seed, in the young plant, its body, root, &c."—*Philos. Trans.* N°. 287.

In answer to this. With regard to vegetables, it is true, that the first seed produces a small tree, which it contained in miniature within its lobes. At the top of this small tree a bud or germ is formed, which contains the shoot or tree that is to spring next season. In the same manner, the small tree of the second year produces a bud which includes a tree for the third year; and this process uniformly goes on as long as the tree continues to vegetate. At the extremity of each branch, buds are likewise formed, which contain, in miniature, trees similar to that of the first year. From these, and similar facts, it is concluded, that all these germs were contained in the original seed; for the first bud was succeeded by a similar bud, which was not unfolded till the second year, and the third bud was not expanded till the third year; and, of course, the seed may be said to have contained not only the whole buds which would be formed in a hundred years, but all the seeds, and all the individuals, which would successively arrive till the final destruction of the species.

These facts are known and established; but the reasoning deduced from them is fallacious, or, what amounts to the same thing, is perfectly incomprehensible. The seed is unquestionably the origin or cause of all future individuals, which may be infinite. But the idea that it really contained the germs of all the individuals which were to spring from it as a source, is not only absurd, but exceeds all the powers of human imagination to conceive. Theories of this kind, of which there are too many in almost every department of science, hardly merit examination. Every seed, and every animal, according to this doctrine, includes in its own body an infinite posterity! If we assent to reasonings of this kind, we must lose ourselves in the laby-

rinths of infinity; and, instead of throwing light upon the subject, we shall involve it in tenfold darkness.

There are even some modern philosophers, who have supposed that the formation of plants and animals is beyond the reach and power of the laws of nature; and therefore they conceive that the Creator himself, in the first individuals of every kind, actually formed and included all the future plants and animals that should ever proceed from them complete in all their parts: and these were contained in their distinct seeds, decreasing in bulk successively in proportion almost infinitely less and less, as the seed is less than the plant or animal, and as each animal and plant in this miniature or minute form, is less than the same plant and animal full grown: and they suppose that the daily productions of nature are nothing else but the unravelling of these little plants and animals in continual succession, bringing them forth into light, and stretching and enlarging their parts by new interwoven fibres, &c.

One great reason they give for this is, that in the minute bud of a plant, suppose a tulip even in the winter, they can, by a microscope, discern the little stalk and leaves of the flower, and the small triangular pod of seed in it: and since matter is infinitely divisible, say they, why may not this minute tulip contain another, and that contain a third, and that a fourth, even to the number of many thousands in their diminished proportions?

To this I answer, 1. That from this one position, viz. That the microscope shews the formation of a perfect plant in its bud a few months before the time of its appearance in full growth, it is a vast leap to the conclusion, that therefore it may contain thousands and millions of such perfect plants in their infinitely decreasing proportions, and that for five or six thousand years before the times of their appearance.

2. Arguments drawn merely from infinites, lead our finite reasoning powers so far out of their own depth, that we are lost in them, and can hardly ever be well assured that our arguments are effectually conclusive, or our inferences well drawn.

3. Suppose every acorn that grew on the first oak should contain, in the germ or bud of it (which is a very small part of the acorn isself), all the oaks that might be produced from thence, even to the end of the world, in one single line of direct succession, this is prodigious and astonishing beyond all reasonable belief: but, according to this hypothesis, we must suppose, that the germs or buds in each of these acorns, do actually contain also the acorns

that those oaks might annually produce, together with all their annual leaves; and again, all the younger oaks which might be produced from each of these acorns in ten thousand collateral successions: now this raises the number to such millions of millions, that nothing but the incomprehensible idea of infinite can ever be supposed to answer; and at best, in this controversy, it seems rather to be a refuge of darkness to hide in, than a clear explication.

4. We find many plants may be produced by slips or twigs of the same plant, and that of trees as well as herbs and flowers, such as the vine, willow, &c. And it is not to be supposed that each twig and slip have all these future seeds and trees actually formed in *them*, together with all their leaves and fruits the first week of the creation, even though we should allow every *seed* to contain all these infinite successions of their species.

5. Have we not reason to conceive that every seed of a plant is formed alike? Has not then every acorn and every bean that is devoured by animals for their food, and every grain of corn, as well as all the fruits of the trees and their seeds which are eaten by men and birds, the same millions of these complete trees or plants, corn or herbage, contained in them in miniature which are ascribed to those other seeds and fruits which are actually sown or planted out, in order to produce new vegetables of their own kind? Now if it be so, what an infinite number of complete trees, flowers, plants, and herbs, would be made by the exquisite artifice of the Creator to no purpose? And thus a vastly greater part of the original and immediate workmanship of God in the first week of creation would be labour in vain, since none of it attains its proper end, but only in those few seeds and fruits which afterwards grew up into complete plants or trees.

6. When a limb of an animal, or some necessary part of a plant, has been broken off, what powerful efforts have sometimes been observed in the operations of nature towards the formation of a new limb, or part of the same kind? I have seen the claw of a crab rising up in a less form, in the room of one which the creature seems to have been deprived of by some injurious accident: now I would inquire, whether this creature was formed at first, in its minute original, with three claws? Or whether there was an actual provision made for every such accident in the first week of the creation?

In the vegetable world these regular productions of the new parts of a plant are much more common. When the top of an ash is cut off to make a pollard of it, or of a plumb-tree to make it bear more, or better fruit, I beg

leave to inquire, whether all the branches, leaves, and fruit, that sprout afterwards from the stock yearly, were formed actually in the first ash, or plumb-tree, that God created? Did the Creator provide actually sufficient leaves and fruit in every first tree to answer for such voluntary mutations of the gardener in five thousand years to come? How unreasonable it is to suppose this!

But, on the other hand, if the natural laws of motion are left to form the limb of an animal, or part of a vegetable, on such occasions, why might not the same Divine Wisdom contrive laws which might form the whole animal or vegetable in its appointed successions in the course of nature?

7. In the formation of insects, and especially of larger animals, daily experiment destroys this hypothesis, by shewing us, that the animal, in several parts and members of it, is imperfect and defective in the embryo, the work is unfinished, and the laws of nature finish it by degrees, till it becomes ripe for production.*

I think this argument is conclusive alone, but all these considerations put together, give us abundant reason to believe, that it is by the continual and uniform agency of God upon the material world, according to certain laws of matter and motion which he has appointed in the vegetable and animal world, that there is a continual succession of plants and animals through all ages; and the honour of such a wonderous contrivance is due to the great Creator.†

---

* This account seems more exactly conformable to the words of scripture, Psalm cxxxix. 16. Thine eyes did see my substance, yet being imperfect, and in thy book my members were written, which in continuance were fashioned, when *as yet* there were *none* of them.

† Perhaps, after all, it may be inquired here, whether plants and animals can possibly be formed by the mechanical motions and powers of matter? To this I answer, If by the word mechanical we mean nothing else but those motions and powers which proceed from the essential properties of matter considered as a mere solid extended substance, then I cannot allow the proposition to be true: but if we include in the word mechanism, all those additional powers and motions also, which arise from the original laws of motion which God imposed upon matter at first, such as gravitation or mutual attraction, and others of the same kind, then I allow that all things, in the successive ages of the world, are formed mechanically; always supposing the Divine Agency preserving all the atoms of matter and their motions, according to these laws. And it is my opinion, that all beyond this is miracle. God is great and wonderous in all his works!

SECT. XXVIII.

ON THE DISSECTION OF SEEDS.

Hence the tall *oak*, the giant of the wood,
Which bears Britannia's thunders on the flood;
The whale, unmeasur'd monster of the main,
The lordly lion, monarch of the plain,
The eagle soaring in the realms of air,
Whose eye undazzled drinks the solar glare,
Imperious Man, who rules the bestial crowd,
Of language, reason, and reflection proud,
With brow erect who scorns this earthly sod,
And views himself " the image of his God;"
Arose from rudiments of form and sense,
An embryon point, or *microscopic ens*.

DARWIN.

THE general rule of dissecting seeds, even the most recent, is by putting them into warm water, in order to free them of their integuments, especially such as have hard ones. When the seeds have been somewhat softened, one of them is to be taken out of the water, and first divided into two equal parts by a transverse section, made from the front to the back, and the divided portions are to be again instantly thrown into water, that the plane of the section may freely imbibe it. Afterwards this softened plane is to be examined by a lens of moderate magnifying power, by which means a threefold difference is generally detected: for, *first*, the plane is manifestly divided, from one wall of the seed to the other, by a simple transverse chink containing no matter of a *different colour* within it: or, *secondly*, the plane is marked with a shorter transverse chink, or a roundish areola, in both which a foreign and *different-coloured* matter appears; and in this case the seed is safely pronounced to be *albuminous*, and to contain an *embryo* longer than half the albumen: or, *thirdly*, no vestige whatever of a *chink* or *areola* can be detected, but the plane appears very uniform and homogeneous; and then we may be very certain that either a very large *false-monocotyledonous embryo* constitutes the whole nucleus of the seed, as in PAULLINIA; or that a *minute embryo* must remain

somewhere in the *albumen,* and either in the superior or inferior segment of the divided seed. In this last case, which is by far the most frequent, a new section is to be made in another seed, which will divide it, according to its axis, into two equal parts.

The segments being again thrown into water, are to be treated in the same manner exactly as the transverse segments; by this means the *embryo,* unless it be extremely minute, may easily be detected in one of the extremities, or the back of the seed, either in the form of a more or less short cylinder, or of a snowy or green globule; and, if the section be rightly made, it sometimes falls spontaneously out of its cavity, and sinks to the bottom of the water.

This very simple process is alone sufficient to detect, and afterwards entirely denude the *embryo,* in by far the greatest number of seeds: but when a seed occurs, possessing a *cartilaginous albumen,* and a *very minute embryo,* as in Asarum, then the examination is to be conducted in a different manner. In this case, at that extremity of the seed, where we suspect the *embryo* to be situated, thin plates are to be repeatedly and carefully cut away from the dorsal and ventral part of the *albumen,* till only the middle very thin plate remains, which is then to be put into water, or oil of turpentine, till it becomes pellucid like glass. By these means, unless the seed be barren, which indeed often happens, the *embryo* will be detected by a good lens, of the form of a snowy medullary point, which, from its whiteness, is not easily distinguished from the *albumen.*

It is not easy to describe in what manner *very minute embryos* of this kind are to be freed from their *albumen,* that they may be farther examined by themselves: this is to be left to the dexterity of each person.

But whether we are desirous of examining seeds, with a view to scrutinize the *albumen* and *embryo,* or on any other account, we ought always to remember that they should be thrown into water, and detained there some time, however fresh they are; for, without this preparation, it can never be learnt, for example, whether they are gelatinous or not, because this quality, even in the most recent dry seed, cannot be detected by the eye; and it can never be known in old seeds, whether they have formerly been berried or not, because the fleshy pellicle, except in moistened seeds, cannot be properly distinguished; not to say any thing of the greater tractability of the moistened *albumen,* and of the less degree of brittleness of the softened *embryo.*

In plants, EMBRYO, the embryo, or germ, is the most essential of all, to which the rest are wholly subservient, and without which no seed is perfect, or capable of vegetation, however complete in external appearance. Linnæus, after Cæsalpinus, names it the *Corculum,* or Little Heart; and it is the point whence the life and organization of the future plant originate, as we have already explained, p. 96. In some seeds it is much more conspicuous than in others. The *Walnut,* the *Bean, Pea, Lupine,* &c. show the *embryo* in perfection. Its internal structure, before it begins to vegetate, is observed by Gærtner to be remarkably simple, consisting of an uniform medullary substance, enclosed in its appropriate bark or skin. Vessels are formed as soon as the vital principle is excited into action, and parts are then developed which seemed not previously to exist, just as in the egg of a bird. In position, the *embryo* is, with respect to the base of the whole flower or fruit, either *erect,* as in the *Dandelion* and other compound flowers; *reversed,* as in the *umbelliferous* tribe; or *horizontal,* as in the *Date Palm.* In situation it is most commonly within the substance of the seed, and either *central,* as in *umbelliferous* plants, or *eccentric,* out of the centre, as in *Coffee*; in *Grasses,* however, it is *external.* Its *direction* is either *straight, curved,* or even *spiral,* in various instances. The *embryo* of seeds that have a single *cotyledon,* or none at all, is peculiarly simple, without any notch or lobe, and is named by Gærtner *Embryo monocotyledoneus.*

COTYLEDONES, the cotyledons or seed-lobes, are immediately attached to the embryo, of which they form, properly speaking, a part. They are commonly two in number; but in *Pinus,* and *Dombeya,* the Norfolk Island Pine, they are more, as already mentioned, p. 98. When the seed has sufficiently established its root, these generally rise out of the ground, and become a kind of leaves. Such is the true idea of the organs in question, but the same name is commonly given to the body of the seed in the *Grass* and *Corn* tribe, the *Palms,* and several other plants, thence denominated *monocotyledones,* because the supposed *cotyledon* is single. The nature of this part we shall presently explain. It neither rises out of the ground, nor performs the proper functions of a *cotyledon,* for what these plants produce is, from the first, a real leaf; or, if the plant has no leaves, the rudiment of a stem, as in *Cuscuta.* In either case, the part produced is solitary, never in pairs; hence Gærtner was led to reckon *Cyamus Nelumbo, Exot. Bot.* t. 31, 32, among the monocotyledonous plants, the body of its seed remaining in the

earth, or its seed-vessel, and the leaves springing one at a time from the *embryo,* just as in the *Date Palm, Wheat, Barley,* &c.

The *seed-lobes* of *Mosses,* according to the observations of Hedwig, *Fund.* part 2. t. 6, are above all others numerous and subdivided, as well as most distinct from the proper leaves; so that these plants are very improperly placed by authors among such as have *no cotyledons,* a measure originating probably in theory and analogical reasoning rather than from observation.

Albumen, the White, is a farinaceous, fleshy, or horny substance, which makes up the chief bulk of some seeds, as *Grasses, Corn, Palms, Lilies,* never rising out of the ground nor assuming the office of leaves, being destined solely to nourish the germinating embryo, till its roots can perform their office. In the *Date Palm, Gærtner,* t. 9, this part is nearly as hard as a stone; in *Mirabilis, Exot. Bot.* t. 23, it is like wheat flour. It is wanting in several tribes of plants, as those with *compound,* or with *cruciform* flowers, and the *Cucumber* or *Gourd kind,* according to Gærtner. Some few *leguminous* plants have it, and a great number of others which, like them, have cotyledons besides. We are not, however, to suppose that so important an organ is altogether wanting, even in the abovementioned plants. The farinaceous matter, destined to nourish their embryos, is unquestionably lodged in their cotyledons, whose sweet taste, as they begin to germinate, often evinces its presence, and that it has undergone the same chemical change as in *Barley.* The *albumen* of the *Nutmeg* is remarkable for its eroded variegated appearance,, and aromatic quality; the *cotyledons* of this seed are very small.

Vitellus, the yolk, first named and fully illustrated by Gærtner, is less general than any of the parts already mentioned. He charactetizes it as very firmly and inseparably connected with the *embryo,* yet never rising out of the integuments of the seed in germination, but absorbed, like the *albumen,* for the nourishment of the *embryo.* If the *albumen* be present, the *vitellus* is always situated between it and the *embryo,* and yet is constantly distinct from the former. The *vitellus* is esteemed by Gærtner to compose the bulk of the seed in *Fuci, Mosses,* and *Ferns,* as well as in the genus *Zamia,* closely allied to the latter, see his t. 3, and even in *Ruppia, Engl. Bot.* t. 136, and *Cyamus.* In the natural order of *Grasses* the part under consideration forms a scale between the *embryo* and the *albumen.*

I cannot but think that the true use of the *vitellus* may be to perform the functions of a *cotelydon* with regard to air if not to light, till a real leaf can be sent forth, and that the " subterraneous cotyledons" of Gærtner in the *Horse Chesnut* and Garden *Nasturtium* are, as he seems to indicate in his Introduction, p. 151, rather of the nature of a *vitellus*. It does not appear that any plant with genuine ascending cotyledons is likewise furnished with this organ; on the other hand, it commonly belongs to such as have the most copious *albumen*, and therefore should seem to answer some other end than mere nutriment, which is supplied by the latter.

We learn, from the above inquiries, that the old distinction between plants with one cotyledon and those with several may still be relied on, though in the former the part which has commonly been so denominated is the *albumen*, as in *Corn*, the real cotyledon of which is the scale or *vitellus*; which last organ, however, seems wanting in *Palms, Lilies*, &c. such having really no cotyledon at all, nor any thing that can perform its office, except the stalk of their embryo.* In the *Horse Chesnut, Oak*, and *Walnut*, possibly, whose seed-lobes do not ascend, the functions of a real cotyledon, as far as air is concerned, and those of the *albumen*, may be united in these lobes, as is the case with most *leguminous* plants; which is rendered more probable, as several of the latter have the corresponding parts likewise remaining under ground. Hence the divided *vitellus* of the *Cyamus* is to be considered as a pair of subterraneous cotyledons, and the plant consequently ranges near its natural allies the Poppy tribe, as Mr. Salisbury, without the aid of physiology, has shown in the *Annals of Botany*,† *v. 2, p. 70, 75.*

---

* This may answer the purpose of a cotyledon, just as the stems of many plants fulfil the office of leaves.

† As to the other parts, to use the language of Gærtner, *Testa*, the skin, contains all the parts of a seed above described, giving them their due shape; for the skin is perfectly formed, while they are but a homogeneous liquid. This coat differs in thickness and texture in different plants. It is sometimes single, but more frequently lined with a finer and very delicate film, called by Gærtner *membrana*, as may be seen in a *Walnut*, and the kernel of a *Peach, Almond*, or *Plum*. In the *Jasmine* a quantity of pulp is lodged between the *membrana* and the *testa*, constituting a pulpy seed, *semen baccatum*, which is distinct from the *acinus*, or grain of a compound berry in the *Raspberry*, the seed of the latter having its proper double covering within the pulp. The *testa* bursts irregularly, and only from the swelling of its contents in germination.

Hilum, the scar, is the point by which the seed is attached to its seed-vessel or receptacle, and through which alone life and nourishment are conveyed for the perfecting its internal parts. Consequently all those parts must be intimately connected with the inner surface of this scar, and they are all found to meet there, and to divide or divaricate from that point, more or less immediately.

In describing the form or various external portions of any seed, the *hilum* is always to be considered as the base. When the seed is quite ripe, the communication through this channel is interrupted: it separates from the parent channel without injury, a scar being formed on each. Yet the *hilum* is so far capable of resuming its former nature, that the juices of the earth are imbibed through it previous to germination.

There are various accessory parts, or appendages, to seeds, which come under the following denominations.

Pellicula, the pellicle, called by Gærtner *epidermis,* closely adheres to the outside of some seeds, so as to conceal the proper colour and surface of their skin, and is either membranous, and often downy, as in *Convolvulus,* or mucilaginous, not perceptible till the seed is moistened, as in *Salvia verbenaca, Engl. Bot.* t. 154. Perhaps the covering of the seed in *Chenopodium,* called by Gærtner *Utriculus,* is merely a *Pellicula.*

Arillus, the tunic, is either a complete or partial covering of a seed, fixed to its base only, and more or less loosely or closely enveloping its other parts. Of this nature is the pulpy orange-coloured coat in *Euonymus,* t. 362, the beautiful scarlet cup in *Afzelia,* and the double membranous coat in *Hippophäe,* t. 425, which last invests the seed within the pulp of the berry. The outer of these coats only is described by Gærtner as a peculiar membrane lining the cell of the berry; his "*integumentum duplex*" refers to the *testa,* which I mention only to prevent misapprehension. The Mace, which envelopes the Nutmeg, is a partial *Arillus,* beautifully drawn in Gærtner, t. 41. *Narthecium, Engl. Bot.* t. 535, has a complete membranous tunic, elongated beyond the seed at each end, as in many of the Orchis tribe; and such seeds, acquiring thence a light and chaffy appearance, have been denominated *scobiformia,* whence Bergius was perhaps led, very unscientifically, to call the seeds of Ferns literally *scobs* or sawdust! An elastic pouch-like *arillus,* serving to project the seeds with considerable force, occurs in *Oxalis,* t. 762 and 1726. In the natural order of *Rutaceæ* the same part, shaped also like a pouch lining each cell of the capsule, is very rigid or horny; see *Dictamnus albus,* or Fraxinella, *Gærtner,* t. 69, and *Boronia, Tracts on Nat. Hist.* t. 4—7. Besides this coincidence, there are many common points of affinity between these plants and *Oxalis,* concerning colour, flavour, habit, and structure. *Fagonia* and its allies form the connecting link between them, which Gærtner and Jussieu did not overlook. We have pointed out this affinity in *English Botany,* p. 762, and it is confirmed by the curious circumstance of Jaquin's *Oxalis rostrata, Oxal.* t. 22, having the very appendages to its filaments which make a peculiar part of the character of *Boronia.*

It is not easy to say whether the various, and frequently elaborate, coat of the seed among the rough-leaved plants, *Borago, Anchusa, Lithospermum, Cynoglossum, Engl. Bot.* t. 921, &c. should be esteemed an *arillus* or a *testa*; but the latter seems most correct, each seed having only a simple and very thin membranous internal skin besides. Gærtner therefore justly uses the term Nut for the seeds in question. The same may be observed of *Ranunculus, Myosurus,* see *Engl. Bot.* t. 435, *Clematis, Anemone,* &c. whose external coats are no less various and elaborate; yet such seeds are as truly naked as those of the *Didynamia* class, figured in Gærtner, t. 66, each having a double skin and no more, which is one covering less than even the genuine nut of the stone fruit, or of the *Corylas.* In *Geranium, Malva,* &c. what has often been called *arillus,* is rather a kind of capsule, not only because their seeds have a double or even triple skin, quite unconnected with this outer cover, but because the latter is analogous to other capsules.

The loose husky covering of the seed in *Carex* is surely an *arillus*; see *Engl. Bot.* also the Rev. Mr. Wood's observations on this genus in Dr. Rees's *Cyclopædia,* and Gærtner, v. 1, 13. This seed has besides a double *testa,* though most of the true *Grasses* have but one, which in ground corn constitutes the bran, the husks of the blossom being the chaff.—From Dr. SMITH's admirable *Introduction to Physiological and Systematical Botany,* p. 299.

SECT. XXIX.

THE SEED THE EMBLEM OF THE RESURRECTION.

Thoughts on beholding a lifeless Body.

Come, reflection, solemn pow'r,
From the grot, and from the bow'r;
From the philosophic cell,
Where devotion's wont to dwell,
And the pure uplifted eye
Meditates its parent sky;
Here, where science courts its ray,
From inanimated clay,
O'er my soul thy influence shed;
Wake the living by the dead.—
What a scope for thought is here!
This is Contemplation's sphere!
Lo, the body pale and cold!
Nature sickens to behold:
There her workings all are o'er;
There the lamp of life's no more.
Life, what art thou?—fickle breath.
Is there nothing certain?—Death.
Tho' with pride the bosom glows;
Tho' it melt at others' woes;
Tho' the passions all rebel;
Tho' in virtue they excel;
Tho' by learning's lore refin'd;
Tho' in ignorance the mind;
Tho' it pant for worldly toys;
Tho' it hope sublimer joys;
Still precarious is our state,
Open to impending fate;
Nought can tyrant Death assuage;
Youth must fall as well as age.
Why, alas! then, all our cares,
All our wishes, all our fears,
When 'tis out of mortal pow'r
To insure the present hour?
Hush, oh, Muse, suspend the strain!
All is just the skies ordain:
Sinks my heart at what I see?
'Tis but what myself must be!

Rise, ye thoughts, to nobler ends!
Melancholy, heav'n offends.
Atheist, if there lives the name,
Come inspect the human frame!
Here thou'lt own th' Almighty's pow'r,
Wonder first, and then adore.
Oh eternal! all divine!
GOD! this glorious work is thine!—
If the body thus is made,
Which in earth must soon be laid,
Can we doubt a pow'r above?
Can we doubt a GOD of love!
We will wait the promis'd day,
MIND outlives the earthly clay;
Those whom death hath overcome,
Taken to his silent dome,
These shall see th' expected ray,
Turning darkness into day,
Lift their eyes, and from afar
Hail the light of Jacob's star!
See the beams intensely shed,
Spread o'er Sion's favour'd head!
Never may we hence remove,
GOD of Truth! and *GOD of Love!*

THE belief of the soul's immortality has prevailed amongst the wise* in every age. PYTHAGORAS delivered to the Greeks the Metemsychosis, or transmigration of the soul. This doctrine is yet prevalent throughout the Eastern world.† It supposes, that the soul, like matter, does never perish,

---

* Vide some elaborate notes on the different religions which have prevailed in the world, in our New Illustration of the Sexual System, when treating on the Indian Canna, and Sacred Egyptian Bean.

† Vide Maurice's learned work on "Indian Antiquities." In the Ode to MITRA, he describes the order of the Deity respecting one of these incarcerated souls.

With fearful prodigies appal his soul;
Around him let terrific lightnings glare,
And the loud thunders of the tropic roll:
While winds impetuous rush, and waves resound,
And rending earthquakes rock the lab'ring ground,
Through the deep windings of the mystic cave,
While midnight darkness hovers o'er,
Let the blind wretch his toilsome way explore!
Now plunge him headlong in the solar snow,
Whelm him in Capricorn's solstitial wave,
Round him let Cancer's burning deluge flow!
Through all the elements that wrap the globe,
The soul that dares to heav'nly birth aspire,
Must strenuous toil,—earth, ocean, air, and fire;
Then, purg'd of all the sordid dross below,
The daring spirit shall with angels glow,
And change its earthly for a heav'nly robe.

but only undergoes a change " omnia mutantur, nihil interit," and migrates into different bodies, as is thus expressed by Ovid,

> Of bodies chang'd to various forms I sing,
> The selfsame soul *still* pointing whence they spring.

For his several metamorphoses proceed from the different embodying of the spirit. Hence Virgil,

> ——————————some have taught
> That bees have portions of ethereal thought,
> Endu'd with particles of heav'nly fires;
> For God the whole created mass inspires:
> Thro' heav'n, and earth, and ocean's depth, he throws
> His influence round, and kindles as he goes.
> Hence flocks, and herds, and men, and beasts, and fowls,
> With breath are quicken'd, and attract their souls:
> Hence take the form his prescience did ordain,
> And into him at length resolve again.
> No room is left for death, they mount the sky,
> And to their own congenial planets fly.

Virgil likewise gives us, in another place, further insight into this doctrine of Pythagoras, that the souls of man, brute, and insect, were emanations from the Deity, and that the soul appeared brighter, or more obscured, according as the systems were organized, which received it:

> Know first, that heav'n and earth's compacted frame,
> And flowing waters, and starry flame,
> And both the radiant lights, *one common soul*
> Inspires and animates the whole.
> This active mind, infus'd through all the space,
> Unites and mingles with the mighty mass:
> Hence men and beasts the breath of life obtain,
> And birds of air, and monsters of the main;
> The ethereal vigour is in all the same,
> And every soul is fill'd with *equal flame*;
> As much as earthly limbs, and gross allay,
> Of mortal members, subject to decay,
> Blunt not the beams of heav'n and edge of day.

Dryden.

> Yon mighty ladder let his feet ascend,
> With sapphires studded, and refulgent gold;
> To heav'n's high arch its lofty steps ascend,
> And sev'n wide gates their radiant valves unfold.
> Of various metals wrought, those portals gleam,
> And, through yon orbs, the souls *migration* shew;
> Now spotless shining in the solar stream,
> Now darkly toiling in the spheres below.
> Where'er he wanders let his lips prolong,
> To him who rolls the spheres, th' exulting song!

Maurice.

But this doctrine of PYTHAGORAS is set forth more fully in Book XV. of Ovid's Metamorphoses:*

---

* Here dwelt the man divine, whom *Samos* bore,
But now self-banish'd from his native shore,
Because he hated tyrants, nor could bear
The chains, which none but servile souls will wear.
He, tho' from heav'n remote, to heav'n could move,
With strength of mind, and tread th' abyss above;
And penetrate, with his interior light,
Those upper depths, which Nature hid from sight:
And what he had observ'd, and learnt from thence,
Lov'd in familiar language to dispense.
The crowd with silent admiration stand,
And heard him, as they heard their God's command;
While he discours'd of Heav'n's mysterious laws,
The world's original, and Nature's cause;
And what was God; and why the fleecy snows
In silence fell, and rattling winds arose;
What shook the stedfast earth, and whence begun
The dance of radiant planets round the sun;†
If thunder was the voice of angry Jove,
Or clouds, with nitre pregnant, burst above:
Of these, and things beyond the common reach,
He spoke, and charm'd the audience with his speech.
He first the taste of flesh from tables drove,
And argu'd well, if arguments could move.
O mortals! from your fellows' blood abstain,
Nor taint your bodies with a food profane:
While corn and pulse by Nature are bestow'd,
And planted orchards bend their willing load;
While labour'd gardens wholesome herbs produce,
And teeming vines afford their gen'rous juice;
Nor tardier fruits of cruder kind are lost,
But tam'd with fire, or mellow'd by the frost;
While kine to pails distended udders bring,
And bees their honey redolent of spring;
While earth not only can your needs supply,
But, lavish of her store, provides for luxury;
A guiltless feast administers with ease,
And without blood is prodigal to please.
Wild beasts their maws with their slain brethren fill;
And yet not all, for some refuse to kill;
Sheep, goats, and oxen, and the nobler steed,
On browse, and corn, and flow'ry meadows, feed,
Bears, tygers, wolves, the lion's angry brood,
Whom Heav'n endu'd with principles of blood,
He wisely sunder'd from the rest, to yell
In forests, and in lonely caves to dwell;

† Pythagoras discovered, or first taught, the true system of astronomy, or what is called the modern Newtonian doctrine.

Where stronger beasts oppress the weak by might,
And all in prey, and purple feasts, delight.
O impious use! to Nature's laws oppos'd,
Where bowels are in other bowels clos'd:
Where fatten'd by their fellows fat, they thrive;
Maintain'd by murder, and by death they live.
'Tis then for nought that mother Earth provides
The stores of all she shows, and all she hides,
If men with fleshy morsels must be fed,
And chew with bloody teeth the breathing bread:
What else is this, but to devour our guests,
And barb'rously renew *Cyclopean* feasts!
We, by destroying life, our life sustain;
And gorge th' ungodly maw with meats obscene.
Not so the golden age, who fed on fruit,
Nor durst with bloody meals their mouths pollute.
Then birds in airy space might safely move,
And tim'rous hares on heaths securely rove:
Nor needed fish the guileful hooks to fear,
For all was peaceful; and that peace sincere.
Whoever was the wretch (and curs'd be he)
That envy'd first our food's simplicity,
Th' essay of bloody feasts on brutes began,
And after forg'd the sword to murder man.
Had he the sharpen'd steel alone employ'd
On beasts of prey, that other beasts destroy'd,
Or man invaded with their fangs and paws,
This had been justify'd by nature's laws,
And self-defence: but who did feasts begin
Of flesh, he stretch'd necessity to sin.
To kill man-killers, man has lawful pow'r,
But not th' extended licence, to devour.
Ill habits gather by unseen degrees,
As brooks make rivers, rivers run to seas.
The sow, with her broad snout, for rooting up
Th' intrusted seed, was judg'd to spoil the crop,
And intercept the sweating farmer's hope:
The covetous churl, of unforgiving kind,
Th' offender to the bloody priest resign'd:
Her hunger was no plea: for that she dy'd.
The goat came next in order to be try'd:
The goat had cropt the tendrils of the vine:
In vengeance laity and clergy join,
Where one had lost his profit, one his wine.
Here was, at least, some shadow of offence;
The sheep was sacrific'd on no pretence,
But meek, and unresisting innocence.
A patient, useful creature, born to bear
The warm and woolly fleece that cloth'd her murderer;
And daily to give down the milk she bred,
A tribute for the grass on which she fed.
Living, both food and raiment she supplies,
And is of least advantage, when she dies.
How did the toiling ox his death deserve,
A downright simple drudge, and born to serve?

O tyrant! with what justice canst thou hope
The promise of the year, a plenteous crop,
When thou destroy'st thy lab'ring steer, who till'd,
And plough'd with pains, thy else ungrateful field?
From his yet reeking neck to draw the yoke,
That neck, with which the furly clods he broke;
And to the hatchet yield thy husbandman,
Who finish'd autumn, and the spring began!
Nor this alone! but Heav'n itself to bribe,
We to the gods our impious acts ascribe:
First recompense with death their tedious toil;
Then call the bless'd above to share the spoil:
The fairest victim must the pow'rs appease,
(So fatal 'tis sometimes too much to please!)
A purple fillet his broad brows adorns,
With flow'ry garlands crown'd, and gilded horns:
He hears the murd'rous pray'r the priest prefers,
But understands not, 'tis his doom he hears:
Beholds the meal betwixt his temples cast,
(The fruit and product of his labours past;)
And in the water views perhaps the knife
Uplifted to deprive him of his life;
Then broken up alive, his entrails sees
Torn out, for priests t' inspect the gods' decrees.
From whence, O mortal men, this gust of blood
Have you deriv'd, and interdicted food?
Be taught by me this dire delight to shun,
Warn'd by my precepts, by my practice won:
And when you eat the well-deserving beast,
Think, on the lab'rour of your field you feast!
Now, since the god inspires me to proceed,
Be that, whate'er inspiring pow'r, obey'd.
For I will sing of mighty mysteries,
Of truths conceal'd before, from human eyes,
Dark oracles unveil, and open all the skies.
Pleas'd as I am to walk along the sphere
Of shining stars, and travel with the year,
To leave the heavy earth, and scale the height
Of *Atlas*, who supports the heavy weight;
To look from upper light, and thence survey
Mistaken mortals wandering from the way,
And wanting wisdom, fearful for the state
Of future things, and trembling at their fate!
Those I would teach; and by right reason bring
To think of *death*, as but an idle thing.
Why thus affrighted at an empty name,
A dream of darkness, and fictitious fame?
Vain themes of wit, which but in poems pass,
And fables of a world that never was!
What feels the body, when the soul expires,
By time corrupted, or consum'd by fires?
Nor dies the *spirit*, but *new life repeats*
In other forms, and only changes seats.
Then, *death*, so call'd, is but *old matter dress'd*,
In some *new figure*, and a vary'd vest:

Thus all things are but alter'd, nothing *dies;*
And here, and there, th' *unbody'd spirit* flies.
By time, or force, or sickness, dispossest,
And lodges, where it lights, in *man* or *beast;*
Or hunts without, 'till ready limbs it find,
And actuates those according to their kind;
From tenement to tenement is toss'd,
The *soul* is still the *same,* the *figure only lost;*
And, as the soften'd wax new seals receives,
This face assumes, and that impression leaves;
Now call'd by one, now by another name;
The form is only chang'd, the wax is still the same:
So *death,* so call'd, can but the form deface;
Th' *immortal soul* flies out in empty space,
To seek her fortune in some other place.
Then let not piety be put to flight,
To please the taste of glutton appetite;
But suffer inmate souls secure to dwell,
Lest from their seats your parents you expel;
With rabid hunger feed upon your kind,
Or from a beast dislodge a brother's mind.
And since, like *Typhis* parting from the shore,
In ample seas I sail, and depths untry'd before,
This let me further add, That nature knows
No stedfast station, but, or ebbs, or flows:
Ever in motion, she destroys *her old,*
And casts *new figures* in *another mold.*
Ev'n times are in perpetual flux, and run,
Like rivers from their fountain, rolling on,
For time, no more than streams, is at a stay;
The flying hour is ever on her way:
And as the fountain still supplies her store,
The wave behind impels the wave before;
Thus in successive course the minutes run,
And urge their predecessor minutes on,
Till moving, ever new: for former things
Are set aside, like abdicated kings:
And every moment alters what is done,
And innovates some act, 'till then unknown.
Darkness we see emerges into light,
And shining suns descend to sable night;
Ev'n heav'n itself receives another dye,
When weary'd animals in slumbers lie
Of midnight ease: another, when the gray
Of morn preludes the splendor of the day.
The disk of *Phœbus,* when he climbs on high,
Appears at first but as a bloodshot eye;
And when his chariot downward drives to bed,
His ball is with the same suffusion red;
But mounted high in his meridian race
All bright he shines, and with a better face:
For there, pure particles of *æther* flow,
Far from th' infection of the world below.
Ev'n our own bodies daily change receive,
Some part of what was theirs before, they leave;

Nor are to-day, what yesterday they were;
Nor the whole same to-morrow will appear.
Thus are our bodies never at a stand,
But chang'd by Nature's innovating hand;
All things are alter'd, nothing is destroy'd,
The shifted scene for some new show employ'd.
Then, to be born, is to begin to be
Some other thing we were not formerly:
And what we call to *die*, is not t' appear,
Or be the thing, that formerly we were.
Those very elements, which we partake
Alive, when *dead* some other bodies make:
Translated grow, have sense, or can discourse;
But *death* on deathless substance has no force.
The grubs from their sexangular abode
Crawl out unfinish'd, like the maggot's brood:
Trunks without limbs; till time at leisure brings
The thighs they wanted, and their tardy wings.
'Tis time my hard-mouth'd coursers to control,
Apt to run riot, and transgress the goal:
And therefore I conclude, whatever lies,
In earth, or flits in air, or fills the skies,
All suffer change; and we, that are of soul
And body mix'd, are members of the whole.
That when our sires, or grandsires, shall forsake
The forms of men, and other figures take,
Thus hous'd, securely let their spirits rest,
Nor violate thy father in the beast,
Thy friend, thy brother, any of thy kin,
If none of these, yet there's a man within:
O spare to make a *Thyestæan* meal,
T' inclose his body, and his soul expel.
Ill customs by degrees to habits rise,
Ill habits soon become exalted vice:
What more advance can mortals make in sin
So near perfection, who with blood begin?
Deaf to the calf, that lies beneath the knife,
Looks up, and from her butcher begs her life:
Deaf to the harmless kid, that ere he dies
All methods to procure thy mercy tries,
And imitates in vain thy children's cries.
Where will he stop, who feeds with household bread,
Then eats the poultry, which before he fed?
Let plough thy steers; that when they lose their breath,
To nature, not to thee, they may impute their death.
Let goats for food their loaded udders lend,
And sheep from winter cold thy sides defend;
But neither sprindges, nets, nor snares, employ,
And be no more ingenious to destroy.
Free as in air, let birds on earth remain,
Nor let insidious glue their wings constrain;
Nor opening hounds the trembling stag affright,
Nor purple feathers intercept his flight:
Nor hooks conceal'd in baits for fish prepare,
Nor lines to heave 'em twinkling up in air.

Plato entertained nearly the same opinion as Pythagoras. He says, "that all corporeal bodies are inhabited by the soul, and owing to this terrestrial body, arise all the gross appetites." Being perplexed, how to account for this union, considering, as he did, the perfect goodness of God, he supposes "that the soul had previously existed, and had, even in a more exalted state, contracted some impurity, and was in consequence confined to do penance in some body, or form; and hence, that all bodies are a sort of prison, or house of correction." He compares "the soul to a pilot governing a vessel, and even though a shipwreck should arise, the pilot might escape by swimming, so upon death, the soul would escape from the mouldering body, forming no more a part of it, than the pilot did of a ship." He wrote an express treatise "on the immortality of the soul."

Socrates, the contemporary with Plato, was among the wise ancients, who believed in the immortality of the soul. Having raised an altar to the "unknown God," he was persecuted by the religious bigots of the times, and when pleading before his judges, he says, "Death is of all things the most desirable, being a transmigration out of one state into another, and the bettering one's condition, as the good then live with men of unspotted virtue, and elevated minds." Being condemned to die, he was offered to be rescued from prison by his friends. But he thus refused. "Truly, if I did not firmly believe, that I am going to a just God, and to the company of men, better than those now living, I were inexcusable for contemning life. But I am perfectly assured, that I am going to a Supreme Being, the best of masters, and to the fellowship of good men, having no doubt, as I have often said, that the soul of man subsists after death, and it is better to live with the good in another world, than with so many bad in this."

Whilst the executioner was preparing the draught, he kept on discoursing on the soul, and was advised not to speak so much, for it would heat the blood, and hinder the poison from taking so speedy an effect. But such a consideration could have no effect upon Socrates; he went on addressing his friends. "That the good man had no reason to fear death, but

---

Take not away the life you cannot give,
For all things have an equal right to live.
Kill noxious creatures, where 'tis sin to save;
This only just prerogative we have:
But nourish life with vegetable food,
And shun the sacrilegious taste of blood.

Dryden.

rather to rejoice at it. That they who had defiled their minds with vice, and given themselves up to sensual pleasures, and committed crimes against society, where secluded from the presence of God; whereas those who have preserved themselves from all vice, and imitated the purity of God, would find by death a road opened to them to the Divine Presence, whence they took their original. And as swans are said to sing before death, as supposing they have some insight into the good arising from death, so should every good man rejoice at the approach of death, leading to another and better state. Let each of you prepare for the appointed time. You, my friends, must all go, when God calls. Me the fates summon." Alluding to a line of Euripides.

When he had made an end of speaking, Crito asked him, "in what manner he wished to be buried." He replied, "that is with me a matter of little, or no concern. Have I been so long discoursing, and not yet persuaded, Crito, that when Socrates has drunk the poison, the soul of Socrates hath left the body to possess the joys of the blessed, and he himself is slipt away. Let it not be said, that Socrates is being buried, that Socrates is here deposited. For such an expression is doing wrong to me, my immortal part. Say rather, that here lies the carcase of what once belonged to Socrates, and do with it whatever you please." He then drank off the poison.

Xenophon, who was the pupil of Socrates, in recording the last words of Cyrus, shews how much he had imbibed the sublime notions respecting the soul and God from his master. He describes this amiable prince, when on his death-bed, thus addressing his family and friends:

"My dear children and disconsolate friends, think not that I shall be no more. While with you and about you, my soul has always been invisible, yet from my actions you were persuaded of its existence. My soul will still remain unseen; but conceive of it as existing. Never could I once imagine that the soul only lived while united to a mortal body, or that it died on being separated from it."

Anaxarchus of Cyprus was pounded to pieces in a tub. "You may," says this philosopher, "beat to pieces the bag of Anaxarchus, but you cannot strike Anaxarchus himself."

Epicarmus asserts, "that death could not destroy his spirit, it was immortal, and would happily live in heaven."

Thus, at the judgment seat of Nero, Thraseas told the emperor,

"although he might pass sentence of death on his body, he could not destroy Thraseas."

CICERO, speaking of the soul, says, "that it is a being that could not be seen, nor tangible, yet must be allowed to exist. Throughout nature there is no swiftness which can compare with the flight of thought. The mind, it soars aloft beyond the compass of sea or land, sporting throughout the vastness of infinite space. Such lively powers, do they not speak its divine extraction, alliance, and duration?" Speaking of his death, he says, "Oh! illustrious day! when I shall escape from the multitude, a heap of pollution, and be admitted to that divine assembly of exalted spirits! When I shall behold again my son, whose soul is looking down upon me, and expecting that shortly we shall meet."

CATO,* who had eyes too pure to live, when his country was enslaved, and without hope of being able to render it the least assistance, resolved to die. He is reported, by Cicero, thus to have discoursed. "Since the mind can exert itself with such a remembrance of the past, such concern for the future, since it is enriched with so many arts, sciences, and discoveries, it is impossible but that this must be of a divine nature, and hence immortal; and that when it shall have quitted this frail body, it will be admitted to the divine assembly of exalted spirits in heaven."

SENECA, when speaking of the dignity of the soul, says, "I am of too noble an origin to be a *slave* to my body, which I only consider as the prison of my soul. At death, although the union betwixt soul and body be dissolved, the soul will still continue to exist without it. Is it possible the soul can perish, unless that can die which is immortal!"

With what triumph, and with what classic elegance, doth the ROMAN POET exult:

Non omnis moriar, multaque pars mei
Vitabit. HORACE.

————man, tho' dead, retains
Part of himself. Th' immortal mind remains.

---

* He is thus made to reason by our immortal Addison:

It must be so—Plato, thou reasonest well;
Else, why this pleasing hope, this fond desire,
This longing after immortality?
Or whence this secret dread and inward horror
Of falling into nought? Why shrinks the soul
Back on herself, and startles at destruction?
'Tis Heav'n itself that points out an hereafter,
And intimates eternity to man!

But amongst no people did sublimer notions of God, and a future state, prevail, than with the Jews. David, their king, sings,

" Thou, Lord, in the beginning hast laid the foundation of the earth: and the heavens are the work of thy hands:

They shall perish, but thou shalt endure: they all shall wax old as doth a garment;

And as a vesture shalt thou change them, and they shall be changed: but thou art the same, and thy years shall not fail.

The children of thy servants shall also continue: and their seed shall stand fast in thy sight.—

Praise the Lord, O my soul; and all that is within me praise his holy name.

Praise the Lord, O my soul: and forget not all his benefits;

Who forgiveth all thy sin: and healeth all thine infirmities;

Who saveth thy life from destruction: and crowneth thee with mercy and loving-kindness;

Who satisfieth thy mouth with good things: making thee young and vigorous as an eagle.

The Lord executeth righteousness and judgment: for all them that are oppressed with wrong.

He shewed his ways unto Moses: his works unto the children of Israel. The Lord is full of compassion and mercy, long-suffering, and of great goodness.

He will not alway be chiding: neither keepeth he his anger for ever.

He hath not dealt with us after our sins: nor punished us according to our wickednesses.

For look how high the heaven is in comparison of the earth: so great is his mercy also toward the children of men!

Look also how wide the east is from the west: so far hath he set our sins from us.

Yea, like as a *father* pitieth *his own children,* even so is the Lord *merciful* unto them that fear him:

For he knoweth whereof we are made: he remembereth that we are but dust.—

The days of man are but as grass: for he flourisheth as a flower of the field:

For as soon as the wind goeth over it, it is gone: and the place thereof shall know it no more.

But the merciful goodness of the LORD endureth for ever and ever upon them that fear HIM: and HIS righteousness upon children's children;

Even upon such as keep HIS covenant: and think upon HIS commandments to do them.

The LORD hath prepared HIS seat in heaven: and HIS kingdom ruleth over all.

O praise the LORD, ye angels of HIS, ye that excel in strength: ye that fulfil HIS commandment, and hearken unto the voice of HIS words.

O praise the LORD, all ye HIS hosts: ye servants of HIS that do HIS pleasure.

O speak good of the LORD, all ye works of HIS, in all places of HIS dominion: praise thou the LORD, O my soul."

EZEKIEL, if any thing, speaks more explicit. "At the word of the LORD," says the prophet, "in a valley filled with bones, the bones came together, bone to bone; the sinews and flesh came upon them, and the skin covered them above; and the breath came into the bodies, and they lived, and stood upon their feet, a great army!"—*Ezek.* ch. xxxvii. v. 5.

ISAIAH also speaks of the resurrection. "Thy dead shall live; together with my dead body shall they arise: awake, and sing, ye that dwell in the dust; for thy dew is as the dew of herbs, and the earth shall cast out the dead."—*Isaiah,* ch. xxvi. v. 19.

There is also a passage of JOB pointing out the resurrection of the body. "I know that my Redeemer liveth, and that he shall stand at the latter day upon the earth; and though after my skin worms destroy this body, yet in my flesh shall I see GOD."—*Job,* ch. xix. v. 25.

Whether these passages of scripture be fairly translated, or not, it is not our business to inquire. It is sufficient for our purpose, that, at any rate, the Jews had sublime notions of GOD and of the Resurrection at the time of the appearance of CHRIST. For Martha, speaking of her brother Lazarus, says to our Lord, "I know that he shall rise again in the resurrection at the last day." This resurrection appears to have been an established opinion among the Pharisees; for although it was a notion of the sect of the Sadducees that there was no resurrection, neither angel nor spirit, yet the Pharisees, we are told, confessed both. And this assertion is completely confirmed by St. Paul himself, when his countrymen accused him before Felix. "I confess unto thee (says this inspired apostle), that after the way which they call heresy, so worship I the God of my fathers, believing all

things which are written in the law and the prophets, and having hope towards God, which they themselves also *allow*, that there shall be a *resurrection of the dead*, both of the just and unjust."—*Acts*, ch. xxiv. v. 15.

Christ, after proving his divine mission by the miracles which he wrought, and by the completion of ancient predictions in which he was described, declared that the doctrine of a resurrection was one of those truths which he came upon earth to announce. The first miracle of this sort which Jesus performed is thus recorded by St. Matthew (ch. ix. v. 18.): Whilst Jesus was speaking, a ruler came, and, prostrating himself, said, "My daughter is dead; but come, and lay thy hand upon her, and she will live." Being come into the ruler's house, and seeing the mourners lamenting, he addressed them, and said, "Mourn not, but depart; for the ruler's daughter is not dead, but only asleep; and they laughed at him: but the mourners being desired to depart, he took the lady by the hand, and she immediately arose. Now the fame of this miracle spread through all that neighbourhood."

In chap. xi. there is also this account: "Now John having heard, when in prison, of the miracles of Christ, sent two of his disciples, who asked, Art thou the Messiah, or are we to expect another? Jesus said unto them, Go, and tell John what ye have heard and *seen*. The blind are made to see, the lame to walk, the deaf to hear; lepers are cleansed; the *dead* are raised; and good tidings is brought unto the poor; and happy is he to whom I shall not prove a stumbling-block."

In chap. xvi. "After six days Jesus took Peter, and James, and John, brother of James, apart to an high mountain, and was transfigured in their presence. His face shone as the sun; and his raiment became white as the light; and presently appeared to them Moses and Elijah conversing with him."

Again, chap. xxiv. "Graves also burst open, and after the resurrection the bodies of several saints who slept were raised, came out of the graves, went into the holy city, and were seen by many."

Again, chap. xxviii. "Now there was a great earthquake, and an angel of the Lord descended from heaven, who having rolled the stone from the entrance, sat upon it. His countenance shone like lightning, and his apparel was as white as snow. The angel said, "Jesus, who was crucified, is not here; he is risen, as he foretold."

This being told to the disciples of Jesus, they ran towards the vault,

and Jesus met the foremost, saying, "Rejoice; tell my apostles to repair to Galilee, and I will appear before them."

And the eleven went to Galilee, and Jesus accordingly appeared before them, and instructed them.

St. Mark, in chap. v. tells us, "that this ruler was one of the directors of the synagogue, named Jairus, and also mentions the very words of our Lord, 'Talitha cumi,' which signifies, 'Damsel, arise, I command thee;' and likewise the age of the daughter, 'she was twelve years old:' and the multitude who followed were confounded and astonished."

In chap. iv. according to the same apostle, Jesus said, "This night I shall prove a trial for you all; for it is written (*Ezek.* xiii. 7, and chap. xvi. 7.), I will smite the Shepherd, and the sheep shall be dispersed. Nevertheless, after I am raised, I will go before you to Galilee."

In chap. xvi. speaking of the angel who had rolled back the stone of the monument, his person is more particularly described. "Entering into the monument, they beheld a *youth* sitting on the right side, clothed in a white robe, and they were frightened. But he said to them, Be not frightened; ye seek Jesus of Nazareth; he is risen; he is not here. He is gone to Galilee, where ye shall see him, as he hath told you."

This evangelist further relates, "that Jesus being *arisen* on the Sunday, first appeared to *Mary Magdalene*, then to *two disciples*, then to the *eleven* disciples, who being more minute than Matthew, says, they were, when Jesus appeared, at *meat*, and relates what our Saviour says to them; after which he was taken up to heaven, and sat down at the right hand of God."

In St. Luke we have an account of raising one who was dead (chap. viii. beginning verse 11), not mentioned by the other two evangelists. "Jesus went into the city called Nain, accompanied by his disciples, and a great multitude. As he approached the gate of the city, the people brought out to him a dead man, the only son of his mother, and she was a widow; and many friends were with her. When the Lord saw her, he had compassion for her, and said, Weep not. Then he advanced, and touched the bier, the bearers stopping, and he said, 'Young man, arise, I command thee.' Then he who had been dead, sat up, and began to speak, and Jesus delivered him to his mother. All who were present were struck with awe, and glorified God, saying, 'A great prophet has come among us; God hath sent him to our nation.' And this report was spread throughout all Judea, and the neighbouring country."

In the xxth chapter of St. LUKE we have the following clear exposition of the state of departed souls. "Afterwards some of the Sadducees, who deny a future state, came to him with this question: 'Rabbi, Moses hath enjoined in his writings that a man whose brother dieth childless outlived by his wife, shall marry the widow, in order to continue the family. Now there were seven brothers, the eldest of whom having taken a wife, died childless; the second married the widow, and also died childless; the third married her, as did likewise the rest; and all the seven died without children. Last of all the woman died. To which of them, at the resurrection, shall she be the wife?' JESUS answered to them, 'The people of this world marry; but amongst them who shall be accounted worthy of the resurrection in heaven, there will be no marrying, neither can they die any more, being children of the resurrection. That the dead are raised, Moses hath shewn, calling the Lord, who appeared to him in a bush, 'The God of Abraham, of Isaac, and of Jacob.' For GOD is not the God of the dead, but of the living; for they that are dead to us, are alive* to him."

In the gospel of St. JOHN we have an exclusive account of Lazarus being raised from death. "Now one Lazarus of Bethany, the brother of Mary and her sister Martha, was sick. They sent to acquaint JESUS of it. 'Master, lo, he whom thou lovest is sick.' JESUS hearing this, said, "This sickness shall not occasion his loss to them, but shall conduce to the glory of GOD, that the Son of man may be glorified thereby.' After a few days, JESUS addressed his disciples, and said, Our friend Lazarus is dead; but I shall go to awake him. Then said his disciples, If he sleep, he will awake, and recover. JESUS spake of his death, but they thought he only spoke of the repose of sleep. Then JESUS told them in plain terms, Lazarus is dead, and on your accounts I am glad I was not there at the time of his departure, that ye may have the more faith: but let us go to him. When JESUS arrived Lazarus had been dead already four days. Now Bethany being two miles from Jerusalem, many of its inhabitants had come to Martha and Mary to console with them on the death of their brother Martha hearing that JESUS was approaching went out to him; but Mary remained in the house. Then Martha said to JESUS, 'Master, if thou hadst been here, my brother had not died. But I know that even now whatsoever thou shalt ask of GOD, GOD will give it.' JESUS replied, 'Thy brother shall rise

---

* Alluding to the intermediate state, or state of the departed soul in *Paradise*.

again.' Martha answered, ' I know that he will rise at the resurrection at the last day.' Jesus said to her, ' I am the resurrection and the life. He that believeth in me, though he were dead, he shall live; and the person who liveth, shall never die. Believest thou this?' She answered, ' Yes, Master, I believe that thou art the Messiah, the Son of God, he who was to come into the world.' Having said this, she ran back, and told her sister Mary. The Jews observing them both running out, followed, saying, ' She is going to the tomb, to weep there.' Mary, when she arrived to where Jesus was, threw herself at his feet, saying, ' Hadst thou been here, Master, our brother had not died.' When Jesus saw her weeping, and the Jews weeping who came with her, Jesus was also troubled, and sighed, and he inquired where he was laid. They answered, ' Come with us, and see the tomb.' Jesus wept. The Jews observed this, and said amongst themselves, ' See how he loves him! Could not he who gave sight to the blind man, have prevented his friend's death?' They came to the tomb; it was a cave, the entrance of which was shut with a stone. Jesus said, ' Remove the stone.' Martha, the sister of the deceased, answered, ' Sir, by this time the body is offensive, for this is the fourth day since his burial.' Jesus replied, ' Said I not unto thee, if thou believe, thou shalt see the glory of God?' Then they removed the stone. And Jesus, lifting up his eyes, said, ' Father, I thank thee, that thou hast heard me. As for me, I know that thou hearest me always; but I speak for the people's sake who surround me, that they may believe that thou hast sent me.' After these words, raising his voice, he cried, ' Lazarus, come forth.' And he who had been dead came forth, bound hand and foot with fillets, and his face wrapped in a handkerchief. Jesus said to them, ' Unbind him, and let him free.' All were filled with astonishment."

At the next festival of the passover, when the scheme of Caiaphas was put in execution, and when it was deemed expedient by the council that he should die, to save the nation from the jealousy of the Romans; as a proof of their steady loyalty to Rome he was apprehended, was tried as an enemy to her government, was at last condemned upon false evidence, and suspended on a cross until they were fully satisfied of his death. Even after his death, the spear of a soldier was thrust into his side; and the water that gushed out with the blood is a proof to those who are acquainted with the structure and economy of living bodies, that he must have been some time dead.

After he was taken down from the cross, a seal was put on the door of the sepulchre in which he was laid, as the best check against secret fraud; and a guard of soldiers was stationed around it, as the best security against open violence. In spite, however, of all these precautions the prediction was accomplished; the angel of God, descending from heaven with a countenance like lightning, and with raiment white as snow; the watch shake, and become as dead men; the earth quakes; the stone is rolled from the mouth of the sepulchre; the angel sits on it, and our Lord comes forth.

It was in vain for the Jews to allege that his disciples came in the night, and stole him away, while the watch were asleep. One must smile at these puerile assertions. How came the disciples to know that the watch were asleep; or what excuse had the watch for sleeping, and incurring a punishment which they knew to be capital in the Roman law? and how came they, in the name of wonder, to be brought as an evidence for those transactions that happened at the time when they were asleep?

Whatever credit may be given by modern infidels to this ill-framed story, it is past dispute that it had none among the Jewish rulers at the time it was current. Not long after our Saviour's resurrection, the apostles were called before the council, and threatened with death for teaching in the name of Jesus. Their boldness upon that occasion was so provoking to the rulers, that the threat would have been instantly put in execution, had not Gamaliel, a doctor of the law of high reputation, put them in mind of other impostors who had perished in their attempts to mislead the people; and concluded a very sensible speech with these remarkable words: "And now, I say unto you, refrain from these men, and let them alone; for if this counsel, or this work, be of men, it will come to nought; but *if it be of God,* ye cannot overthrow it, lest haply ye be found even to fight against God." This advice the council followed. But is it possible that Gamaliel could have given it, or the council paid the least regard to it, had the story of the disciples stealing the body been then credited? Surely some among them would have observed, that a work or counsel, founded on imposture and fraud, could not be *supposed to be of God,* and they would unquestionably have slain the apostles.

The story of stealing the body is indeed one of the most senseless fictions that ever was invented in support of a bad cause. Our Lord was on earth forty days after he arose. He appeared frequently to his disciples. He ate and drank in their presence; and when some of them doubted, he

bade them handle him and see that he was not a spectre, showed the mark of the spear in his side, and the prints of the nails in his feet and hands. Besides thus appearing to his disciples, he was seen by more than five hundred brethren at one time; all of whom, as well as his disciples, must necessarily have known him previous to his suffering, and could therefore attest that he was the person who was once dead, but was then alive. Yet for strangers in general, who had not seen him previous to his death, and could not therefore identify his person after he arose, our Lord reserved many other proofs that were equally convincing. Before his ascension, he bade his disciples wait till they received power, by the Holy Ghost descending upon them: that then they should be witnesses with him, both in Jerusalem, and in all Judea, and in Samaria, and unto the uttermost ends of the earth; in order that the people of all these nations, observing the miracles wrought in his name, might themselves become ocular witnesses that those who preached his resurrection were warranted to do so by his authority; and that this authority, on which so numerous miracles attended, must be divine.

We next find the apostle PAUL teaching the resurrection of the dead. "If, after the manner of men, I have fought with beasts at Ephesus, what advantageth it me, if the dead rise not?—Let us eat and drink, for to-morrow we die. Be not deceived. Evil communications corrupt good manners. Awake to righteousness, and sin not. Another will say, 'How can the dead be raised?' and a third, 'With what body can it rise?' Thou fool, that which thou *sowest* is not quickened, except it die,—and that which thou *sowest* is not that body which ariseth, for each *seed* hath its own peculiar body, perchance of wheat, or some other grain. For GOD hath given it a body, as it hath pleased him, and to every *seed* its own body. So all flesh is not the same flesh; for there is one flesh of men, another of beasts, another of fishes, and another of birds. There are also celestial bodies, and bodies terrestrial; but the glory of the celestial is one, and the glory of the terrestrial another. There is one glory of the sun, another glory of the moon, and another glory of the stars; for one star differeth from another star in glory. So also is the *Resurrection of the Dead.* The body is sown in corruption, it is raised in incorruption; it is sown in dishonour, it is raised in glory; it is sown in weakness, it is raised in strength; it is sown a natural body, it is raised a spiritual body. Flesh and blood cannot inherit the kingdom of heaven; nor can corruption inherit incorruption.

Behold! I shew you a mystery. We shall not all sleep, but we shall all be changed, in a moment, in the twinkling of an eye, at the last trump; for the trumpet shall sound, and the dead shall be raised incorruptible, and we shall be changed. For this corruptible must put on incorruption, and this mortal must put on immortality. So when this corruptible shall have put on incorruption, and this mortal shall have put on immortality, then shall be brought to pass the saying that is written, 'Death is swallowed up by victory. O death! where is thy sting? O grave! where is thy victory?" (First Epist. to the Corinthians, ch. xv. v. 20.)

But in order to render the matter under consideration more unquestionably clear and certain, we will compare St. John's account of the *first* and *second* resurrection states, as it lies in the Apocalypse, with St. Matthew's description of the day of judgment and other passages allusive to it, to be met with in the sacred pages.

CHAP. XX.

1. And I saw an Angel come down from heaven, having the key of the bottomless pit, and a great chain in his hands.

2. And he laid hold on the Dragon, that old serpent, which is the Devil and Satan, and bound him a *thousand* years.

2. And cast him into the bottomless pit, and shut him up, and set a seal upon him, that he should deceive the nations no more, till the *thousand* years should be fulfilled: and after that he must be loosed a little season.

4. And I saw thrones, and they sat upon them, and judgment was given to them: and I saw the souls of them that were beheaded for the witness of Christ, and for the word of God, and which had not worshipped the beast, neither his image, neither had received his mark upon their foreheads, or in their hands; and they lived and reigned with Christ a *thousand* years.

5. (But the rest of the dead lived not again until the thousand years were finished.) This is the *first* resurrection.

6. Blessed and holy is he that hath part in the *first* resurrection: on such the second death hath no power, but they shall be priests of God, and of Christ, and shall reign with him a *thousand* years.

7. And when the *thousand* years are expired, Satan shall be loosed out of prison.

8. And there shall go out to deceive the nations, which are upon the

earth, *Gog* and *Magog*,* to gather them together to battle: the number of whom is as the sand of the sea.†

9. And they went upon the breadth of the earth, and compassed the land of the saints about, and the beloved city: and fire came down from God out of heaven, and devoured them.

10. And the *Devil*, that deceived them, was cast into the lake of fire and brimstone, where the *Beast*‡ and the *false Prophet*§ are, and shall be tormented both day and night, for ever and ever.

11. And I saw a great white throne, and HIM that sat on it, from whose face the heaven and the earth fled away, and there was found no place for them.

12. And I saw the *dead*, both *small* and *great*, stand before God; and the books were opened: and another book was opened, which is the book of life: and the dead were judged out of those things which were written in the books, according to their works.

13. And the sea gave up the dead which were in it; and *Death* and *Hell* which were in them; and they were judged every man according to his works.

14. And *Death* and *Hell* were cast into the lake of fire. This is the *second* death.

15. And whosoever was not found written in the book of life, was cast into the lake of fire.**

Chap. xxi. 1. And I saw a *new* heaven, and a *new* earth; for the first heaven and the first earth were passed away; and there was no sea."

---

* Great warriors; that is, two great thieves, and two great murderers, full of kingly pride and ambition.

† These were the children of the righteous, who had forsaken the precepts of the Lord.

‡ *Buonaparte*, as many conjecture, whose name even is prophetically designated.

§ *Mahomet*, a prophet and a warrior!

** We are not literally to understand this that the damned are cast into *a lake of fire*, eternally to endure torments, but only, that their sufferings will be great, and of an extraordinary kind, as many experience in this life, and of very long duration; but all this is only preparatory to another state of existence, for "*God keepeth not his anger for ever; for God is love.*" John, iv. 8. And St. Paul says, "*that this is acceptable in the sight of God, who wills that* ALL *men shall be saved, and come to the knowledge of the truth.*" 1 Tim. ii. 3. Again: "*For there is one God, and one Saviour, Jesus Christ, who gave himself a ransom for* ALL." 1 Tim. ii. 4. Again: "*Therefore we both labour and suffer reproach, because we trust in the living* God, *who is the saviour of* ALL *men.*" 1 Tim. iv. 10. And we are also told of Christ appearing to the wicked in *Paradise*. "*For* Christ *also hath once suffered for sins, the just for the wicked, that he might bring us to* God, *being put to death in the flesh, but made alive in the spirit: by which also he went and* PREACHED TO THE SPIRITS IN PRISON, *which long ago were disobedient, when formerly*

the long-suffering of God *waited in the days of Noah, when the ark was in preparing, wherein few, that is, eight souls, were saved on the water.*" 1 Pet. iii. 18—20. "*And it shall come to pass in that day, that the* Lord of Hosts *shall punish the host of the high ones that are on high, and the kings of the earth upon the earth, and they shall be gathered together as prisoners are gathered into the pit, and shall be shut up in prison, and* AFTER MANY DAYS (*i. e.* YEARS) THEY SHALL BE VISITED." Isaiah, xxiv. 21. Again: *I will not contend for ever, neither will I be always wroth: for so the spirits would fail before me, and the souls which I have made.*" Isaiah, vii. 16. How consonant is this doctrine to all the ideas we ought to entertain of God, of his mercy, his goodness, and his punishments! A contrary doctrine has crept into the brains of some men from a wrong translation and understanding of several of the passages of scripture. For what is translated "*punish*" is κολαζειν, "to correct," "chastise," after the manner of a *parent*; and when the term "*for ever*" is used, this is expressed by αἰων, meaning "any indefinite time." It is most extraordinary, that any one should attempt to represent God in a light that so much militates against his first and highest attributes, mercy and goodness. But to prove that this is no singular opinion of mine, I shall only quote a few authors out of an innumerable number.

In anno 1658 there was published a small book, entitled, *Of the Torments of Hell,* &c. *the Foundation shaken and removed; with many infallible Proofs that there is not to be a Punishment that shall never end.* Page 180 the author writes, "Such torments, of such continuance, in the least agree not to the gracious mind and merciful heart of a Saint—he desires not any man or creature to be in such torment an hour; therefore it doth in no way agree to the mind of God. We find, the more the Lord manifests himself in any, the more their minds and spirits are humbled, the more loving and merciful they are, even to their enemies, and can return them good for evil. Christ is full of love and mercy to the worst of men. It was truly said of Christ, *that he was a friend of publicans and sinners.*"

1. In a quarto book, printed anno 1563, intitled, *God's Light declared in Mysteries,* page 12, he says, 'Now, what is *hell* or *darkness?* 'Tis a separation from an enjoyment that it was capable of; and a dreadful punishment in another world. They shall not come forth till they have paid the utmost farthing; then shall they receive mercy. For know, that God is good, and just, and merciful, and he will not punish a finite thing infinitely."

2. Richard Coppin, in his book called *Truth's Testimony,* printed 1655, says, "God hath declared in scripture, both by the mouths of his prophets and apostles, the salvation of *all* men, without respect of persons, 1 Tim. iii. 4—6. He *will have all men to be saved, and to come to the knowledge of the truth.*"

3. William Erbury, minister in South Wales, appointed by the committee in Oliver Cromwell's time, at a salary of 100*l.* per annum, preached publicly the *restoration of all men,* and is charged by Mr. Edwards, in his *Gangrena,* p. 109, with holding many gross errors, one of which was that of *Universal Redemption.* This Erbury, although he had nothing to depend on for the support of himself and family but this salary, was obliged to throw it up, his conscience accusing him of preaching for hire. He published a treatise on that account, called *The Terror of Tythes,* alluding to the anxiety of his mind whilst he received them.

4. In 1660 the Rev. Jeremiah White, chaplain to Oliver Cromwell, published a work, entitled, *The Restoration of all Things;* or, *A Vindication of the Goodness and Grace of* God, *to be manifested at last in the Recovery of his whole Creation out of their Fall.*

5. The Rev. Dr. Thomas Burnet, Master of the Charter House, and author of a book entitled, *The Theory of the Earth,* left a treatise in Latin, that was not printed in English before his death, entitled, *The State of departed Souls.* Page 343 he says, "The soul flies from the thought, and the remembrance, of everlasting misery: and several things have occurred to me, while I have been thinking on this subject, by which I am sensible that others have been persuaded, as well as myself, That God neither will or can endure the perpetual affliction and torment of his own creatures."—Page 344, "That God should condemn his own creatures to a state of eternal misery, and should retain them in that state, seems to be repugnant both to divine *wisdom* and *goodness,* and I may add, likewise, to *justice.*"

6. The late pious Rev. William Law, so well known for his great learning, in his *Letters,* 1st edit. 8vo. printed in 1760, says, page 175, "As for the purification of all human nature, either in this world or some after ages, I fully believe it."

By the *angel* coming down from heaven, we are doubtless to understand the second advent of our SAVIOUR descending from thence to take possession of *that* kingdom of which he had received a promise from on high, and of which he was before sent to invite mankind to become with him joint-partakers. And that the purity, peace, and prosperity, of that kingdom might receive no interruption or alloy, for at least a thousand years to come, the Angel, we are told, will restrain the power of sin and *Satan* for *that* time; will lay hold of the dragon, as St. JOHN expresses it, that old serpent, which is the devil and *Satan,* and bind him a *thousand* years, and cast him into the bottomless pit, and shut him up, and set a seal upon him, so as that neither *he* nor *his* shall rise to deceive the nations any more, *until* the *thousand years* are fulfilled. During this period of time, the souls of the good and righteous, *the souls of them that were beheaded for the witness of* CHRIST, *and for the word of* GOD, and *which had not* worshipped *the beast, neither had received* his *mark upon their foreheads, or in their hands* (in which class will be comprehended the extremely good and righteous in general); all these are to live and reign with CHRIST. But *the rest of the dead* rose not till the thousand years are fulfilled. " *Blessed and holy is he that*

The reader who wishes to enter more into this subject will peruse with satisfaction the following works:

1. A Discourse on Predestination, from ROM. viii. 29, 30; in which GOD'S Design of Mercy to ALL Mankind, in the Choice of SOME, is demonstrated. By A. BENNETT.
2. *Universal Restitution* a Scripture Doctrine. By STONEHOUSE.
3. CHAUNCY on *Universal Salvation.*
4. Essay on *Universal Redemption.* By JOHN BROWNE, M. A.
5. *Endless Misery* Overthrown. By JAMES WEAVER.
6. Thoughts on *Divine Goodness.* By OLIVER PETITPIERRE. One of the most pious and learned books ever written.
7. Two Sermons on *Universal Restoration.* By F. LEICESTER, A. B.
8. Trial of the Witnesses of the Resurrection of JESUS, by Dr. SHERLOCK, with a Preface by W. VIDLER.

I will here conclude with a wish that those who preach a contrary doctrine would most attentively peruse these admirable lines of POPE:

Let not this weak and erring hand
  Presume thy bolts to throw,
And deal *damnation* round the land
  On each I judge THY foe.

If I am *right,* THY grace impart
  Still in that *right* to stay;
If I am *wrong,* O teach my heart
  To find that *better way.*

hath part in the first resurrection."*—But in length of time, or when the MILLENNIUM, mentioned by St. JOHN, be expired, *Satan* shall regain his power; shall "*deceive the nations which are in the four quarters of the earth, shall travel over the whole breadth of the earth, shall compass the camp of the saints, and the beloved city*;" till at last, "*fire shall come down from heaven and devour them.*"

Writers, both of the Old and New Testament, having declared that another world will arise from the dissolution of that which we now inhabit, by fire, the Evangelist gives us, in the xxth chap. a short and summary view of those several important events which that *new* heaven and *new* earth will

---

* CHRIST'S REIGN DESCRIBED.

As the good shepherd tends his fleecy care,
Seeks freshest pasture and the purest air,
Explores the lost, the wand'ring sheep directs,
By day o'ersees them, and by night protects,
The tender lambs he raises in his arms,
Feeds from his hand, and in his bosom warms;
Thus shall mankind CHRIST's guardian care engage,
The promis'd father of a *future age.*
No more shall nation against nation rise,
Nor ardent warriors meet with hateful eyes,
Nor fields with gleaming steel be cover'd o'er,
The brazen trumpets kindle rage no more;
But useless lances into scythes shall bend,
And the broad falchion in a ploughshare end.
The lambs with wolves shall graze the verdant mead,
And boys in flow'ry bands the tyger lead;
The steer and lion at one crib shall meet,
And harmless serpents lick the pilgrim's feet;
The smiling infant in his hand shall take
The crested basilisk and speckled snake,
Pleas'd the green lustre of their scales survey,
And with their forky tongue shall innocently play.
Rise, crown'd with light, imperial *Salem*, rise!
Exalt thy tow'ry head, and lift thy eyes!
See a long race thy spacious courts adorn;
See future sons and daughters, yet unborn;
See heav'n its sparkling portals wide display,
And break upon *thee* in a flood of day.
No more the rising Sun shall gild the morn,
Nor ev'ning Cynthia fill her silver horn;
But lost, dissolv'd in thy superior rays,
One tide of glory, one unclouded blaze
O'erflow thy courts: the LIGHT himself shall shine
Reveal'd, and GOD's eternal day be thine!

POPE.

produce.* The inhabitants will consist, probably, of a twofold race; prior the one to the other, by a long interval of time, termed by the apocalyptic Apostle, a *thousand* years; the former constituting what the Evangelist calls the *first* resurrection, the latter consisting of those reviviscent souls, whom he stiles, the *rest of the dead,* who lived not again, he tells us, till after the *thousand years* were expired. Those of the *first* resurrection will be such only, as had distinguished themselves, while here on earth, by their exemplary piety, patience, and perseverant purity of faith and manners, and the *souls of those who were beheaded for the witness of* JESUS, *and for the word of* GOD, &c. Those of the *second* resurrection will be the *rest of the dead,* whom we are to consider, as standing opposed to the *blessed* and *holy* ones, who are to have a part in the *first* resurrection. " This *new* earth," says ADDISON, in his *Spectator,* " may, for aught we know, be placed contiguous to the residence of GOD."

Blessed and holy is he that hath part in the first resurrection: they shall be priests of GOD *and of* CHRIST, *and shall reign with him a thousand years. At that time the Moon shall be confounded, and the Sun ashamed, when the* LORD OF HOSTS *shall reign in* MOUNT SION *and in* JERUSALEM, *and before his ancients gloriously.*—ISAIAH, xxiv. 21.

The *first,* in short, are those who shall, the *second* such as shall *not,* enter into that *kingdom of Heaven,* which in some places is called the *Holy City*; in others, the *new Jerusalem*; in others, the *city of God*; that *kingdom of Heaven,* which was the constant subject of our SAVIOUR and his apostles' ministry *here,* and with a more *immediate* view to which, as introductory to the *final state* of the blessed, they directed all their prophecies, parables, and other more open instructions and exhortations—that *kingdom of Heaven,* foretold by JOHN THE BAPTIST; referred to when he came *preaching in the wilderness of Judea, and saying, Repent ye, for the kingdom of heaven is at hand,* MATT. ii. 2. For, as says the Evangelist, this is he that was spoken of by the prophet ESAIAS, saying, the voice of one crying in the wilderness, *Prepare ye the way of the* LORD, *make his paths straight*; the chapter to which the Evangelist refers being predictive throughout of CHRIST's *king*-

---

* Of *old,* says the PSALMIST, *hast thou laid the foundations of the earth,* and the heavens are the work of thy hands; they shall perish, but thou endurest; yea, all of them shall wax old, like a garment, as a vesture shalt thou change them, and they shall be changed; but thou art the same.

Behold, says ISAIAH, *I make a new heaven, and a new earth, and the former shall not be remembered nor come into mind.*

But we look for new heavens, and a new earth, says St. PETER.

dom, which will take place at the conversion of Jews and Gentiles, and be completed by the *resurrection* of the *saints,* to reign with him a *thousand* years. And that this will be in reality the case, I am fully convinced, by observing from St. MATTHEW's gospel, that St. JOHN and our SAVIOUR united in allotting it to the good and righteous, and that the latter speaks of it afterwards in terms descriptive of that kingdom of CHRIST on earth, which the apocalyptic Apostle calls the *first resurrection.*

Now when JESUS, says St. MATTHEW, *heard that John was cast into prison, he departed into Galilee,* &c. and from that time he began to preach, and to say, as JOHN before had said, and with a view to the same event most certainly, or St. MATTHEW would not have failed pointing out the *difference*; he began to preach and to say, " *Repent ye, for the kingdom of heaven is at hand*;" and made it the constant subject of his pious ministry; *plainly* pointing out the *approach* of it to his *disciples,* in that most excellent sermon from the *mount*; at other times shadowing it out to them in *parables*; and at length, in express terms, commanding them to petition first, in that most solemn form of words, which makes, with the utmost propriety, an oft-repeated part of our *public* liturgy—" *When ye pray, say—Our* FATHER, *which art in heaven, hallowed be thy name*; *thy kingdom come*; *thy will be done in earth, as in heaven,*" &c. that *kingdom of Heaven* wherein *there is joy in the presence of angels—which no man taketh away*—that *kingdom of Heaven,* wherein they, who shall be thought worthy to inherit it, *will be blessed*—wherein *the righteous shall shine forth as the sun*; and into which *the wicked shall not enter*; but on the contrary, that *kingdom of Heaven,* in short, to be enjoyed by the righteous, but the wicked excluded from it. And this will be that same state of glory and happiness, which St. JOHN describes in the apocalypse, I am convinced, because several circumstances relative to the one agree exactly with some particulars, mentioned by our SAVIOUR and his apostles, respecting the other.

Blessed, says our SAVIOUR, *are they which are persecuted for righteousness sake, for theirs is the kingdom of Heaven.*

Blessed are ye when men shall revile you and persecute you, and shall say all manner of evil against you falsely, for my sake. Rejoice, and be exceeding glad, for great is your reward in heaven; *for so persecuted they the prophets which were before you.* That is, *they* were, as will some of you my disciples be, *persecuted unto the death*; *were slain with the sword, were beheaded,* &c. Agreeably to all this, says the apocalyptic Apostle in his description of the *first resurrection state, I saw the souls of them that were beheaded for the*

witness of God, &c. and they lived and reigned with CHRIST a *thousand* years.

Again, says JESUS to his disciples, *Verily I say unto you, that ye which have followed me in the* regeneration, when the SON OF MAN shall sit upon the throne of his glory, *ye shall* sit upon twelve thrones *judging the twelve tribes of Israel.*

That by sitting on the throne of his glory we are to understand the triumphant splendour of CHRIST in the kingdom of Heaven, the preceding verses evince, wherein our Saviour, after having represented the kingdom of Heaven as not easily attainable by those who are *rich,* tells his disciples, that an enjoyment of some distinguished blessings and honours therein shall be the happy portion of themselves and others, *who had forsaken all and followed him.*

And how exactly does this state of glory, promised to his disciples upon the abovementioned occasion, answer to that which is ascribed by St. JOHN to the partakers of the *first resurrection*? *They shall be priests of* GOD and of CHRIST, and shall reign with him a *thousand years.* And I JOHN saw the holy city, new Jerusalem, coming down from Heaven, &c. And I heard a great voice out of Heaven, saying, Behold, the *tabernacle of* GOD *is with men,* and he will *dwell* with them; and they shall be his people, and GOD himself shall be with them, and be their GOD. He that overcometh shall inherit all these things.*

It being then, I think, sufficiently proved that the kingdom of Heaven, which the gospel teaches the good and righteous to expect in an hereafter, is that state of glory and honour which the Evangelist ascribes to the

---

* If it be urged that the *first resurrection,* here mentioned, is not to be understood in a *literal,* but in an allegorical or mystical sense, signifying only a resurrection from sin to a spiritual life (as we are said to be *dead* in sin, and to be *risen* with Christ by faith and regeneration), and that this manner of speech which St. Paul does sometimes use, as in *Ephes.* ii. 6, 14, and in *Coloss.* iii. 1. I ask how that can be applied to the present case? Were the martyrs dead in sin? 'Tis they that are raised from the dead; or after they were beheaded for the witness of Jesus, naturally dead and laid in their graves, were *they* the *regenerate by faith?* Besides, why should they be said to be regenerate a thousand years before the day of judgment? or to reign with Christ after this spiritual resurrection for a limited time—a thousand years? Why not to eternity? For in this *allegorical* sense of rising and reigning they will reign with him for ever. Then, after the thousand years, must all the wicked be regenerate and rise into spiritual life? 'Tis said here, the rest of the dead lived not again until the thousand years were finished. That implies, that, at the end of these thousand years, the rest of the dead did live again, and supposes, agreeably to the imagined allegory, that after a thousand years all the wicked will be regenerate and raised into a spiritual life: a conclusion which the abettors of an *allegorical* sense will not, I apprehend, be easily inclined to admit.—See Dr. BURNET's *Theory.*

partakers of the *first* resurrection in the apocalyptic vision, it is evident that both must correspond with each other, as in the nature and degree of felicity appropriated to each respectively, so also is the very circumstance of duration.

It is moreover observable, from St. John's account of things, in the chapter above considered, that the judgment of the righteous and wicked will be so far from being cotemporary, that there will be a very considerable distance of time, the one from the other.

For a *thousand years* will elapse before *Satan* shall be loosed out of prison; at which time, and not before, it seems evident, that the *rest of the dead,* viz. the *wicked,* shall arise and * repossess the earth; where being put upon a fresh trial of their conduct, many will walk after the advice and counsel of their old deceiver the Devil; *will go upon the breadth of the earth, and compass the camp of the saints about, and the beloved city, and fire shall come down from heaven and destroy them*; the *good,* and *first* possessors of the *New Jerusalem,* they of the *first* resurrection, retiring from it—up into that Heaven of Heavens where they will *see* God. And then, but not *till then,* the day of judgment for the *wicked* will take place; for immediately after the above account of things, St. John tells us as follows: and *I saw the dead, both small and great* (by which dead he undoubtedly means that *dead* which *lived* not again until the thousand years were finished), *stand before* God, *and the books were opened, and another book was opened, which is the book of life*; *and the dead were judged out of those things which were written in the books, according to their works.* From whence it is evident that the judgment of the righteous and wicked, described by St. Matthew, will be by no means cotemporary; but, on the contrary, that a resurrection of the wicked to *another trial* of behaviour upon earth, will take place before *their* day of judgment begins, and their sentence εις κολασιν αιωνιον ensue. This, I think, I shall be able to make appear more unquestionably true, by inquiring further into the particulars, mentioned by St. Matthew, respecting our Saviour's *second coming* to judge the world; observable as well in his xxivth chapter, as in other parts of his gospel.

When the Son of Man, says he, *shall come in his glory, and all his holy angels with him, then shall he sit upon the throne of his glory, and before*

---

* I have supposed that they, who rebelled, were the children of the saints; the learned Dr. Berrow, in his Theological Dissertations, entertains, with many others, the doctrine expressed above of the wicked having a *second trial* upon earth. The essence of Christianity, I am happy to say, does not consist in these difficult interpretations.

him shall be gathered all nations: and he shall separate them one from another, as a shepherd divideth the sheep from the goats; and he shall set the sheep on his right hand, but the goats on the left; then shall the king say to them on his right hand, Come, ye blessed of my Father, inherit the kingdom prepared for you from the beginning of the world.

Now by the *sheep on the right hand,* we must undoubtedly understand the righteous, who are to go εις ζωην αιωνιον; or St. John's *blessed* and *holy,* who are to have a part in the *first* resurrection, and are to reign with Christ a thousand years. By the *goats on the left,* are most assuredly meant those who are to go to εις κολασι αιωνιον, or St. John's *rest of the dead,* who are to be *cast into the lake of fire.*

But that these cannot exist at each side of the judge at one and the same time, is evident from this, that the former are to be admitted in consequence of the sentence passed upon them εις ζωην αιωνιον, or, as St. John says, shall reign with Christ a thousand years, *before* the rest of the *dead,* the *wicked* (the goats on the left), shall live again, and of consequence *before* they can become capable of being judged at all. *Come, ye blessed of my* Father, *receive the kingdom prepared for you from the beginning of the world.* Now what other kingdom is it possible our Saviour can here mean, than that kingdom in which, St. John tells us, the saints are to reign with Christ a thousand years?

Previous, however, to a possession of their complete state of happiness there will be a judgment passed even upon the saints themselves, and all those that shall have a share in the *first resurrection.* Agreeably to which, says St. Paul, we must all appear before the judgment seat of Christ, that *every one* may receive the things done in his body, according to that he hath done, whether it be good or bad. By the pronoun *we,* the Apostle meant to include himself, that eminent church at Corinth, to which he was then writing, and all the elect people of God; intimating that the end and design of Christ's judging the world would be, in the first place, to distribute rewards to *him* and *all the other saints,* in proportion to their respective deserts. For it is neither necessary, nor even warrantable, to suppose that all will arise entitled to the same degree of happiness indiscriminately in the kingdom of heaven.

Again: it will perhaps be urged that St. Paul's account of the second coming of Christ, in his epistle to the Thessalonians, and of the immediate consequent effects of it, plainly prove that the righteous will arise at once to

their full *final* happiness; and that, upon that supposition, my whole hypothesis falls to the ground.

The Lord *himself,* says he, *shall descend from Heaven with a shout, with the voice of the archangel, and with the trump of* God, *and the dead in* Christ *shall rise* FIRST.

Then we which are alive and remain shall be caught up together with them in the clouds to meet the Lord *in the air, and so shall we ever be with the* Lord.

To this I answer, that the apostle's meaning in this passage is, in general, this, that those which are alive upon earth, at the coming of Christ, those righteous ones I mean, shall be carried by the angels into the clouds, there to meet the Lord, and appear before him, and being judged worthy to inherit his kingdom, they shall never *depart* from him, but shall enjoy his presence for ever; that in the mean time, and, as *introductory* to their *final joy* and *glory,* they must first descend with Christ, and reign with him in the new Heaven and new earth, for a *period of time,* termed by St. Matthew ζωην αιωνιον.

And as a strong proof that the epithet αιωνιον is no scripture term by which to express the idea of an *eternal* state, it is observable, that when the Apostle intimates that the consequence of the *first* resurrection and reign with Christ upon earth εις ζωην αιωνιον for an age, would be a continuance with Christ *for ever,* and so shall we *ever be* with the Lord; it is observable, that the Apostle does not say—and so we shall be εις τον αιωνα, but παντοτε, with the Lord; there is likewise observable from the above texts, a very strong argument to be drawn in favour of my hypothesis, concerning a *twofold* and *successive* resurrection, it being therein positively declared that the *dead in Christ* shall rise first, which strengthens very sufficiently all I have said concerning St. John's *rest of the dead,* which are, undoubtedly, such as are *not* dead in Christ, and who will not be *Christ's at his coming.*

The ancients have likewise endeavoured allegorically to represent the *resurrection* by the consideration of the *butterfly,* for the word ψυχη, in Greek, signifies both the *soul,* and the *butterfly*; and this proceeds from a *caterpillar* crawling upon earth—which, after an appointed time, retires to a very considerable depth beneath the surface of the earth (I mean the major part), where it divests itself of all appearance of its former state, forms a tomb, becomes a chrysalis, and continues buried for several months, then emerges from its apparently lifeless state, and rises to the surface, and commences a

being of powers so comparatively exalted, and of beauty so superior, as to be one of the most elegant of the whole insect tribe.*

The inquisitive reader may yet wish to inquire still deeper into the state of man after death, and to know, before the *first* and *second* resurrection, where the unembodied spirit is placed, and what is its condition? Scripture has kindly unfolded this mysterious part of the dispensations of PROVIDENCE, and in the parable of the Rich Man and Lazarus we have a clear explanation, recorded in chapter xvi. of Luke.

"There was a rich man, who was clothed in purple, and fine linen, and fared sumptuously every day. And there was a certain beggar named Lazarus, who was laid at his gate full of sores; and desiring to be fed with the crumbs which fell from the rich man's table: moreover, the dogs came

---

* A fine poet thus elegantly describes this metamorphose, or change:

The helpless crawling *caterpillar* trace,
From the first period of its reptile race.—
Cloth'd in dishonour, on the leafy spray
Unseen he wears his silent hours away.
Till satiate grown of all that life supplies,
Self-taught, the voluntary reptile lies.
Deep under earth his darkling course he bends,
And to the tomb, a willing guest, descends;
There long secluded in his lonely cell,
Forgets the sun, and bids the world farewel.
O'er the wide world the wint'ry tempests reign,
And driving snows usurp the frozen plain:
In vain the tempest beats, the whirlwind blows;
No storms can violate his grave's repose.—
But when revolving months have won their way,
When smile the woods, and when the zephyrs play,
When laughs the vivid world in summer's bloom,
He bursts, and flies triumphant from the tomb,
And while his new-born beauties he displays,
With conscious joy his alter'd form surveys.
Mark, while he moves amid the sunny beam,
O'er his soft wings the varying lustre gleam.
Launch'd into air, on purple plumes he soars,
Gay Nature's face with wanton glance explores;
Proud of his various beauties wings his way,
And robs the fairest flow'rs, himself more fair than they,
And shews to man death's awful power is vain,
If *worms* can DIE, and *glorious* RISE AGAIN.

SHAW.

Allegorical of this, we have in ancient sculpture *Cupid* holding a *butterfly* on his finger, expressive of *divine love*, shewn in the new embodying of the spirit, for there were two Cupids, an heavenly and earthly Cupid. So in our scripture, "*God is love.*" JOHN.

and licked his sores. And it came to pass that the beggar died, and was carried by the angels into Abraham's bosom: the rich man also died, and was buried. And in hell (hades) he lift up his eyes, being in torments, and seeth Abraham afar off, and Lazarus in his bosom. And he cried, and said, 'Father Abraham, have mercy on me, and send Lazarus, that he may dip the tip of his finger in water, and cool my tongue, for I am tormented in this time.' But Abraham said, 'Son, remember that thou in thy life time receivedst thy good things, and likewise Lazarus evil things; but now he is comforted, and thou art tormented. And besides all this, between us and you there is a great gulf fixed; so that they who would pass from hence to you, cannot; neither can they pass to us that would come from thence.' Then he said, 'I pray thee therefore, father, that thou wouldst send him to my father's house, for I have five brethren; that he may testify unto them, lest they also come into this place of torment.' Abraham saith unto him, 'They have Moses and the prophets; let them hear them.' And he said, 'Nay, father Abraham; but if one went unto them from the dead, they will repent.' And he said unto him, "If they hear not Moses and the prophets, neither will they be persuaded though one rose from the dead."

According to this history, the rich man and Lazarus were both in *hades*, though in very different situations; the latter in the mansions of the happy, and the former in those of the wretched. Let us see how the circumstances mentioned, and the expressions used, in the parable, will suit this hypothesis. First, though they are said to be at a great distance from each other, they are still within sight and hearing. This would have been too gross a violation of probability, if the one were considered as inhabiting the highest heavens, and the other as placed in the infernal regions. Again, the expressions used, are such as entirely suit this explanation, and no other; for, first, the distance from each other is mentioned, but no hint that the one was higher in situation than the other; secondly, the terms, whereby motion from the one to the other is expressed, are such as are never employed in expressing motion to or from heaven, but, always, when the places are on a level, or nearly so. Thus, Lazarus, when dead, is said* απενεχθῆναι, *to be carried away*, not ανενεχθῆναι, *to be carried up*, by angels into Abraham's bosom; whereas, it is the latter of these, or one similarly compounded, that is always

* Luke, xvi. 22.

used, where an assumption into heaven is spoken of. Thus, the same writer, in speaking of our Lord's ascension, says,* ανεφερετο εις τον ουρανον, and Mark,† in relation to the same event, says, ανεληφθη εις τον ουρανον, *he was taken up into heaven.* These words are also used, wherever one is said to be conveyed from a lower to a higher situation. But, what is still more decisive in this way, where mention is made of passing from Abraham to the rich man, and inversely, the verbs employed are, διαβαινω and διαπεραω, words which always denote motion on the same ground or level; as, passing over a river or lake, passing through the Red Sea, or passing from Asia into Macedonia. But, when heaven is spoken of as the termination to which, or from which, the passage is made, the word is, invariably, either in the first case, αναβαινω, and in the second, καταβαινω, or some word similarly formed, and of the same import. Thus, both the circumstances of the story, and the expressions employed in it, confirm the explanation I have given. For, if the sacred penmen wrote to be understood, they must have employed their words and phrases in conformity to the current usage of those for whom they wrote.

When our Saviour, therefore, said to the penitent thief upon the cross,‡ *To-day shalt thou be with me in Paradise,* he said nothing that contradicts what is affirmed of his descent into *hades,* in the Psalms, in the Acts, or in the Apostles creed. *Paradise* is another name for what is, in the parable, called Abraham's bosom. But it may be urged, on the other side, that Paul has given some reason to conclude that paradise and heaven, or the seat of the glorious hierarchy, are the same. *It is not,* says he,§ *expedient for me doubtless to glory: I will come to visions and revelations of the* LORD. *I knew a man in* CHRIST *above fourteen years ago (whether in the body I cannot tell, or whether out of the body* (the soul unembodied), *I cannot tell,* GOD *knoweth), such an one was caught up to the* THIRD HEAVEN.—*And I knew such a man (whether in the body, or out of the body, I cannot tell,* GOD *knoweth), how that he was caught up into* PARADISE, *and heard unspeakable words, which it is not lawful for a man to utter.* The Jews make mention of three heavens. The *first* is properly the atmosphere where the birds fly, and the clouds are suspended. The *second* is above the first, and is what we call the visible firmament, wherein the sun, moon, and stars appear. The *third,* to us invisible, is conceived to be above the second, and therefore

---

* xxiv. 51. † Mark, xvi. 19. ‡ Luke, xxiii. 43. § 2 Cor. xii. 1—4.

sometimes styled the heaven of heavens. This they considered as the place of the throne of God, and the habitation of the holy angels. Now it is evident, that if, in the second and fourth verses, he speak of one vision or revelation only, paradise and heaven are the same; not so, if in these he speak of two different revelations. My opinion is, that they are two, and I shall assign my reasons. First, he speaks of them as more than one, and that not only in introducing them, *I will come to visions and revelations*; for sometimes, it must be owned, the plural is used in expressing a subject indefinitely; but afterwards, in referring to what he had related, he says,* *lest I should be exalted above measure, through the abundance of the revelations*, των αποκαλυψεων. Secondly, they are related precisely as two distinct events, and connected together by the connective particle. Thirdly, there is a repetition of his doubts,† in regard to the reality of his translation, which, if the whole relate to a single event, was not only superfluous, but improper. This repetition, however, was necessary, if what is related in the third and fourth verses be a different fact from what is told in the second, and if he was equally uncertain, whether it passed in vision or in reality. Fourthly, if all the three verses regard only one revelation, there is a tautology in the manner of relating it unexampled in the Apostle's writings. I might urge, as a fifth reason, the opinion of all Christian antiquity, Origen alone excepted. And this, in a question of philology, is not without its weight.

I shall only add, that though, in both verses, the words in the English Bible are *caught up*, there is nothing in the original answering to the particle *up*. The Apostle has very properly employed here the word ἁρπαζω, *snatched away*, expressive more of the suddenness of the event, and rapidity, than of the direction of the motion.‡ The only other place in which παραδεισος occurs is in the Apocalypse.§ *To him that overcometh will I give to eat of the tree of life, which is in the midst* του παραδεισου *of the paradise of* God. Here our Lord, no doubt, speaks of heaven; but, as he plainly alludes to the state of

---

* 2 Cor. xii. 7. † verse 2, 3.

‡ The learned reader may peruse the following passage from Epiphanius on this subject, in opposition to Origen. Ουδε ὁ αποςολος υποτιθεται τον παραδεισον ειναι εν τριτω ουρανω; τοις λεπτων ακροασθαι λογων επιςαμενοις· οιδα γαρ ἁρπαγεντα ἑως τριτον λεγων ουρανου. και οιδα τον τοιȣτον ανθρωπον, ειτε εν σωματι, ειτε χωρις σωματος, ὁ θεος οιδεν, ὁτι ἡρπαγη εις τον παραδεισον. δυο αποκαλυψεις μεγαλας ἑωρακεναι μηνυει, δις αναληφθεις εναργως, ἁπαξ μεν ἑως τριτȣ ȣρανȣ, ἁπαξ δε εις τον παραδεισον· το γαρ οιδα ἁρπαγεντα τον τοιȣτον ἑως τριτȣ ȣρανȣ, ιδιως αποκαλυψιν αυτω κατα τον τριτον αναληφθεντι πεφηνεναι συνιςησι· το δε, και οιδα παλιν επιφερομενον τον τοιȣτον ανθρωπον, ειτε εν σωματι, ειτε εκτος του σωματος, εις τον παραδεισον, ἑτεραν αυθις αυτω πεφανερωσθαι κατα τον παραδεισον αποκαλυψιν δεικνυσι. Epiph. Lib. ii. Hær. 44.

§ Rev. ii. 7.

matters in the garden of Eden, where our first parents were placed, and where the *tree of life* grew, it can only be understood as a figurative expression of the promise of the *New Jerusalem,* forfeited by ADAM, but recovered by our Lord JESUS CHRIST.

Thus Isaiah (ch. xiv. v. 9), in the song of triumph on the fall of the king of Babylon, *Hell* (the original word is the same as in the preceding passage) *from beneath is moved for thee to meet thee at thy coming: it stirreth up the dead for thee, even all the chief ones of the earth: it hath raised up from their thrones all the kings of the nations.* Thus, in *Hades,* all the monarchs and nobles, not of one family or race, but of the whole earth, are assembled. Yet their sepulchres are as distant from one another as the nations they governed. Those mighty dead are raised, not from their couches, which would have been the natural expression, had the prophet's idea been a sepulchral vault, how magnificent soever, but *from their thrones,* as suited to the notion of all antiquity, concerning not the bodies, but the shades or ghosts of the departed, to which was always assigned something similar in rank and occupation to what they had possessed upon the earth.

I shall now proceed to examine some passages in the New Testament, wherein the word occurs, that we may discover whether we ought to affix the same idea to it as to the corresponding term in the Old.—The first I shall produce is one, which, being originally in the Old Testament, is quoted and commented on in the New, and is consequently one of the fittest for assisting us in the discovery. PETER, in supporting the mission of his Master, in a speech made to the inhabitants of Judea and Jerusalem, on the famous day of Pentecost, alleges, amongst other things, the prediction of the royal Psalmist, part of which runs thus in the common version:* *Because thou wilt not leave my soul in hell, neither wilt thou suffer thine holy One to see corruption.* The passage is cited from the Psalms,† in the very words of the Seventy, which are (as far as concerns the present question) entirely conformable to the original Hebrew. As this prophecy might be understood by some to relate only to the Psalmist himself, the Apostle shews how inapplicable it is to him, when literally explained. It plainly pointed to a resurrection, and such a resurrection as would very soon

---

* Acts, ii. 27. † Psalm, xvi. 10.

follow death, that the soul should not be left in *hades,* should not remain in the mansion of departed spirits, but should reanimate its body, before the latter had suffered corruption. *Brethren,** says he, *let me speak freely to you of the patriarch* David, *that he is both dead and buried, and his sepulchre is with us to this day.* He has had no resurrection. It was never pretended that he had. His body, like other bodies, has undergone corruption; and this gives sufficient reason to believe that his soul has shared the fate of other souls, and that the prophecy was never meant of him, unless in a secondary sense. "*But,*"† continues he, "*being a prophet, he spake of the resurrection of* Christ," or the Messiah: and, to shew how exactly both what related to the soul, and what related to the body, had their completion in the Messiah, adds, that "*his soul was not left in hades, neither did his flesh see corruption.*"

Besides, we have another clear proof from the New Testament, that *hades* denotes the intermediate state of souls between death and the general resurrection. In the Apocalypse,‡ we learn that *death and hades,* by our translators rendered *hell* as usual, *shall,* immediately after the general judgment, *be cast into the lake of fire. This is the second death.* In other words, the death which consists in the separation of the soul from the body, and the state of souls intervening between death and judgment, shall be no more. To the wicked these shall be succeeded by a more terrible death, the damnation of *gehenna, hell* properly so called. Indeed, in this sacred Book, the commencement, as well as the destruction, of this intermediate state, are so clearly marked, as to render it almost impossible to mistake them. In a preceding chapter,§ we learn that *hades* follows close at the heels of *death*; and, from the other passage quoted, that *both* are involved in one common ruin at the universal judgment. Whereas if we interpret ᾅδης *hell,* in the Christian sense of the word, the whole passage is rendered nonsense. *Hell* is represented as being cast into *hell:* for so the *lake of fire,* which is in this place also denominated the second death, is universally interpreted.

If more is not granted us to know; "if we see, as through a glass darkly;" if it has not even entered into the warmest imagination, "the joys that are prepared for the righteous;" if some things are yet covered in obscurity; still enough is imparted to make us contemplate this life as a

---

* Acts, ii. 29. † 30, 31. ‡ Rev. xx. 14. § Rev. vi. 18.

pilgrimage upon earth; to consider ourselves as sent here upon trial, that after a very few years, which, compared to eternity, amounts to *one* grain of sand to the *whole mass* confining the vast ocean, the *soul* will quit the body, which confines it like a clog upon this earth, and degrades it by its wants, to enjoy in elysian fields, or, as scripture better expresses its true name, in *Paradise*,* there to converse with pure spirits (embodied, or unembodied, we know not), to contemplate new flowers,† more exquisite in shape and beauty than any here on earth, never blighted by mildews, or winter; to behold new animals, new fishes, birds, insects, and shells; to hear the murmuring of numberless rivulets or fountains; the chorusses of birds, not now dreading the hawk or fowler; to see edifices, nay palaces, erected in beautiful architecture of massy jewels; to behold gold and silver, not alloyed for a base currency, but pure, assuming, by finest workmanship, the shapes of all forms of birds, beasts, and flowers; to join often, with heavenly instruments, in praise of HIM, whence all this happiness proceeds; and,

---

* Milton thus describes *Paradise:*

> *Flow'rs of all hue*, and without thorn the *rose*,
> Another side, umbrageous *grots* and *caves*
> Of cool recess, o'er which the mantling *vine*
> Lays forth her purple grape, and gently creeps
> Luxuriant: mean while murm'ring *waters* fall
> Down the slope hills, dispers'd, or in a *lake*,
> That to the fringed bank, with *myrtle* crown'd,
> Her crystal mirror holds, unite their streams.
> The *birds* their quire apply; *airs*, vernal airs,
> Breathing the *smell* of field and grove, attune
> The trembling leaves, while universal PAN,
> Knit with the GRACES and the HOURS *in dance*,
> Led on th' *eternal spring*.

† How exquisitely does Milton describe Eve lamenting the loss of the flowers in Paradise:

> ————————O *flowers*,
> That never will in other climates grow,
> My early visitation, and my last
> At even, which I bred up with tender hand
> From the first opening bud, and gave ye names,
> Who now shall rear you to the sun, or rank
> Your tribes, and water from th' ambrosial fount?
> Thee, lastly, nuptial bow'r, by me adorn'd
> With what to sight or smell was sweet, from thee
> How shall I part, and whither wander down
> Into a lower world, to this obscure
> And wild?

upon the *first* resurrection, to see the appointed time of CHRIST, their Redeemer, reigning upon earth; to become subjects to this heavenly kingdom, and then, being sufficiently purified, at the final day of judgment, in a *second* resurrection, to mount up with the Lord to the *third heaven*, where " GOD sits on his throne, and this is the habitation of HIS glory." It is then " that CHRIST will deliver up the kingdom to the FATHER, and the SON himself will be subject to the FATHER, that GOD may be all in all." 1 COR. XV. 24.)

It is matter of wonder to us now on earth, that the blessed SON OF GOD, who is one with the FATHER, should stoop so low as to unite HIMSELF to a mortal nature, that HE should become a poor despicable man, and pass through a life of sufferings and sorrows, and die an accursed death, to redeem us from guilt and deserved misery: but when we shall see HIM in HIS native glory and lustre, HIS acquired dignities, and all the honours of heaven heaped upon HIM, it will raise our wonder high, to think that such a one should once humble himself to the death of the cross, the death of the vilest slave, that HE might save our souls from dying; that HE should pour out his own blood to wash off the stains of millions of sins, that we might appear righteous before a GOD of holiness. Then shall the multitude of the saved join in that song, *To* HIM *that loved us, and washed us from our sins in* HIS *own blood, be glory and dominion for ever.* REV. i. 5, 6. *Worthy is the* LAMB *that was slain to receive power, and riches, and honour, for* THOU *hast redeemed us with* THY *blood from every kindred, tribe, and nation.* REV. V. 12.

When we see a train of human pomp and grandeur, and long ranks of shining garments and equipage, it is ready to dazzle our eyes, and attract our hearts: vain pomp, and poor equipage, all this, when compared with the triumph of our blessed LORD, at his appearance with an endless army of his holy ones; where every saint shall be vested (not in silks and gold) but in robes of refined light, outshining the sun, such as CHRIST himself wore in the mount of transfiguration. Millions of suns in one firmament of glory.

It is in the THIRD HEAVEN, where reigns the FATHER and the SON, where all the celestial hierarchies, and the innumerable hosts of angels, are represented as perpetually surrounding the seat of GOD with hallelujahs and hymns of praise. This is that presence of GOD which some of the divines call his glorious, and others his majestic, presence. HE is indeed as

essentially present in all other places as in this; but it is here where HE resides in a sensible magnificence, and in the midst of all those splendors which can affect the imagination of created beings.

It is very remarkable that this opinion of GOD ALMIGHTY's presence in heaven, whether discovered by the light of nature, or by a general tradition from our first parents, prevails among all the nations of the world, whatsoever different notions they entertain of the *Godhead.* If you look into Homer, that is, the most ancient of the Greek writers, you see the supreme power seated in the heavens, and encompassed with inferior deities, among whom the muses are represented as singing incessantly about his throne. Who does not see here the main strokes and outlines of this great truth we are speaking of? The same doctrine is shadowed out in many other heathen authors, though at the same time, like several other revealed truths, dashed and adulterated with a mixture of fables and human inventions. But to pass over the notions of the Greeks and Romans, those more enlightened parts of the pagan world, we find there is scarce a people among the late discovered nations, who are not trained up in an opinion that heaven is the habitation of the divinity whom they worship.

As in Solomon's temple there was the *Sanctum Sanctorum,* in which a visible glory appeared among the figures of the cherubims, and into which none but the high-priest himself was permitted to enter, after having made an atonement for the sins of the people; so if we consider this whole creation as one great temple, there is in it the *Holy of Holies,* into which the high priest of our salvation entered, and took his place among angels and archangels, after having made a propitiation for the sins of mankind.

With how much skill must the throne of GOD be erected? With what glorious designs is that habitation beautified, which is contrived and built by HIM who inspired Hiram with wisdom? How great must be the majesty of that place, where the whole art of creation has been employed, and where GOD has chosen to shew himself in the most magnificent manner? What must be the architecture of infinite power under the direction of infinite wisdom? A spirit cannot but be transported after an ineffable manner with the sight of those objects, which were made to affect him by that BEING who knows the inward frame of a soul, and how to please and ravish it in all its most secret powers and faculties. It is to this majestic presence of GOD, we may apply those beautiful expressions in holy writ: "*Behold even the moon, and it shineth not; yea the stars are not pure*

in his sight." The light of the sun, and all the glories of the world in which we live, are but as weak and sickly glimmerings, or rather darkness itself, in comparison of those splendors which encompass the throne of God.

As the glory of this place is transcendent beyond imagination, so probably is the extent of it. There is light behind light, and glory within glory. . How far the space may reach in which God thus appears in perfect majesty, we cannot possibly conceive. Though it is not infinite, it may be indefinite; and though not immensurable in itself, it may be so with regard to any created eye, or imagination. If he has made these lower regions of matter so inconceivably wide and magnificent for the habitation of mortal and perishable beings, how great may we suppose the courts of his house to be, where he makes his residence in a more especial manner, and displays himself in the fulness of his glory, among an innumerable company of angels, and spirits of just men made perfect!

This is certain, that our imagination cannot be raised too high, when we think on a place where omnipotence and omniscience have so signally exerted themselves, because that they are able to produce a scene infinitely more great and glorious than what we are able to imagine.

I have only considered this glorious place with regard to the sight and imagination, though it is highly probable that our other senses may here likewise enjoy their highest gratifications. There is nothing which more ravishes and transports the soul than harmony; and we have great reason to believe, from the descriptions of this place in holy Scripture, that this is one of the entertainments of it. And if the soul of man can be so wonderfully affected with those strains of music which human art is capable of producing, how much more will it be raised and elevated by those in which is exerted the whole power of divine harmony! The senses are faculties of the human soul, though they cannot be employed, during this our vital union, without proper instruments in the body. Why therefore should we exclude the satisfaction of these faculties, which we find by experience are inlets of great pleasure to the soul, from among those entertainments which are to make up our happiness hereafter? Why should we suppose that our hearing and seeing will not be gratified with those objects which are most agreeable to them, and which they cannot meet with in these lower regions of nature; objects, "*which neither eye hath seen, nor ear heard, nor can it enter into the heart of man to conceive?*"

It is very natural for us to take delight in inquiries concerning any foreign country, where we are some time or other to make our abode; and as we all hope to be admitted into this glorious place, it is both a laudable and useful curiosity to get what information we can of it, while we make use of Revelation for our guide. When these everlasting doors shall be opened to us, we may be sure that the pleasures and beauties of this place will infinitely transcend our present hopes and expectations, and that the glorious appearance of the throne of God will rise infinitely beyond whatever we are able to conceive of it. We might here entertain ourselves with many other speculations on this subject, from those several hints which we find of it in the holy Scriptures; as whether there may not be different mansions and apartments of glory to beings of different natures; whether, as they excel one another in perfection, they are not admitted nearer to the throne of the Almighty, and enjoy greater manifestations of his presence; whether there are not solemn times and occasions, when all the multitude of heaven celebrate the presence of their Maker in more extraordinary forms of praise and adoration; as Adam, though he had continued in a state of innocence, would, in the opinion of our divines, have kept holy the Sabbath-day, in a more particular manner than any other of the seven. These, and the like speculations, we may very innocently indulge, so long as we make use of them to inspire us with a desire of becoming inhabitants of this delightful place.

O happy time! when shaking off this clay,
The human soul at liberty shall stray
Through all the works of Nature! shall descry
Those objects which evade the mortal eye!
No distance, then, shall stretch beyond its flight,
No smallness 'scape its penetrating sight;
But, in real essence, shall be shown
Worlds unexplor'd, Creations yet unknown.

SECT. XXX.

DIFFERENT FORMS OF SEEDS.

> The sense how stupid, and the sight how blind,
> Who fails a God in Nature's works to find.
> Oh say, were these the wild result of chance?
> Rather, proud man, confess *thy* ignorance.
>
> Smart.

Seeds present so great a diversity of appearance, that they cannot be grouped into distinct assemblages, but must be presented to the reader individually, of which the following are some of the more striking examples.

1. *A double seed, each resembling a boat* (Semen duplex, naviculæ formam repræsentans), as in the *umbelliferæ.*
2. *Kidney-shaped, with heptagon and pentagon cells* (Reniforme, cellulis pentagonis et heptagonis), as in *Poppy seed* (Semen Papaveris).
3. *Ovate* (Ovatum), shaped like an egg, as in *Eye Bright* (Euphrasia).
4. *Globular* (Globosum), as in the *Pea* (Pisum), and *Coriander* (Coriandrum).
5. *Square* (Tetragonum), having four sides, as in *Foxglove* (Digitalis).
6. *Triangular* (Triangulare), having three sides, as in *Tansy* (Tanacetum).
7. *Cylindric* (Oblongum) oblong, as in *St. John's Wort* (Hypericum.)
8. *Resembling a particular shell* (Figuram Conchæ mentiens), as in *Wood Sorrel* (Oxalis).
9. *Ditto,* as in *Purslane* (Portulaca).
10. *Ditto,* as in *Cinquefoil* (Potentilla).
11. *Resembling the head of a monkey* (Figuram Cynocephali repræsentans), as in the *Cocoa Nut.*
12. *A single crown* (Corona simplex), as in *Ragwort* (Senecio).
13. *A double Crown* (Corona duplex), as in *Holy Thistle* (Centaurea Benedicta).
14. *A Shuttle Cock* (Corona Pennacea), as in *Dandelion* (Leontodon).

SECT. XXXI.

HOW TO PRODUCE SEEDS EARLY IN THE SEASON, AND IN MORE ABUNDANCE.

> First Spring advancing, with her flow'ry train,
> Next Summer's hand that spreads the sylvan scene,
> Then Autumn with her yellow *harvests* crown'd,
> And, lastly, Winter leads the annual round.
>
> SMART.

THOSE plants, which are required to yield a forward crop, as the *peas* and *beans* of our gardens, and those which our cold and short summers will not otherwise perfectly ripen, as *wheat*, should be sowed before the commencement of winter, either in the natural ground, as in the cultivation of wheat, or in situations sheltered from the north-east, as in the garden cultivation of peas and beans; or they may be sowed very thick in hot-houses, or under hot-bed frames, or under warm walls, and be transplanted, when they are one or two inches high, into the natural ground at due distances, when the weather is milder, and the plants are become hardier or less liable to be destroyed from their having longer acquired the habits of life.

When young plants of any kind are transplanted, the ground should be recently dug, as their expeditious growth depends so much on the atmospheric air being buried in the pores or interstices of the earth by the production of carbonic and nitrous acids, and ammonia, and heat.

The same advantage occurs by soaking seeds in water, or in the drainage from manure heaps, till they are ready to sprout, and then sowing them in a soil lately turned over; as their roots will then immediately put out by the newly generated heat, and newly produced carbonic acid in its fluid not its gaseous state.

The transplanting of young roots, if they be set no deeper than before, does not, I suppose, multiply the number of stems, as occurs when wheat is transplanted so deep as to cover the second joint. When the roots of wheat are transplanted and divided, not only a great increase of the crop is produced, but I believe the seed is likewise ripened earlier, as is asserted by Mr. Bogle

(Bath Society, Vol. III. p. 494). And it is well known to gardeners, that transplanting *garden-beans* forwards them in respect to time, but shortens the height of the stem. Hence transplanted vegetables grow less in height, as transplanted *beans,* and less branchy, as transplanted *melons,* but produce and ripen their seeds earlier; which is a great advantage in the short summers of this climate; and if the roots can be divided, as in *wheat,* or new scions can be produced by their being transplanted deeper, as also occurs in *wheat,* the quantity of the seed may also be wonderfully increased by transplanting. (See Phytologia, Sect. XII. 6.)

Another mode of forwarding the production of seeds, and of sooner ripening them, consists in pruning off the viviparous tops or lateral shoots, which will bear no seeds at all, or only small or imperfect ones, in our northern summers. For this purpose, the cutting away the tops of *beans* and of *peas,* and the lateral branches of *artichokes,* after the first fruit-buds are formed, both forwards and enlarges the flowers and *seeds,* which remain, as more nourishment is derived to them.

A due degree of warmth and of dryness seems to include the circumstances principally required to ripen seeds. The warmth not only accelerates the various secretions of vegetables by increasing their irritability and consequent activity, but, after the mucilaginous, starchy, saccharine, and oily matters are secreted into proper reservoirs, may contribute perhaps chemically to their change into each other, or to their greater perfection. And the dryness of the air, whether hot or cold, is necessary to give perfect ripeness to seeds; as otherwise the due exhalation of the aqueous parts of the secreted fluids, which form the nutritive parts of seeds, does not properly proceed; and the seed gathered in this condition is liable to mildew in the barn or granary, or to become shrivelled and wrinkled, as it dries.

It is believed in Scotland, that even the frosty nights of autumn contribute to ripen the late crops in that inclement climate, which some have ascribed to the moonlight, but, which I have indeed suspected, that the frost may in some measure effect by converting the mucilage of the grain sooner into starch. This I was induced to imagine by having observed that bookbinders' paste, made by boiling wheat-flour in water, lost its adhesion after having been frozen; and also from a culinary observation, that when ice or snow is mingled with flour instead of water in making pancakes, that it much improves them; the truth of which I have heard boldly asserted, but never witnessed the experiment.

There is nevertheless an experiment related by Dr. Roebuck in the Edinburgh Transactions, Vol. I. which seems to shew, that the grains of *oats* continue to fill and become heavier even during the autumnal frosts; which may probably occur during the sunshine of the middle part of the day, as occurs in the vernal frosts of this part of the country. In 1780, near Borrowstowness, the *oats* were green even in October, when the ice was three fourths of an inch thick. He selected several stalks of *oats* of nearly equal fulness, cut half of them, and marked the remainder, which continued fourteen days longer in the field; after being dry, the grains of each parcel were weighed; and eleven of those grains, which had remained in the field, weighed thirty of those which had been cut a fortnight sooner.

This important experiment should teach our farmers not to cut their *peas* and *beans* too early in inclement autumns; which are so frequently seen to become shrunk and shrivelled in the barn or granary, and inclined to rot from deficient ripeness, and consequent softness or moisture; and thus contain much less flour in proportion to the husk or bran.

The *wheat* produced after land has been much limed, is believed to be thinner skinned, and to yield more good meal, than other wheat, and to make better bread. On this account I suppose one use of lime is to forward the ripening of seeds by converting the mucilage sooner into starch or oil; as, according to the experiments of M. Parmentier, the goodness of bread depends much on the quantity of starch contained in it; who found, that if the starch taken from eight pounds of raw *potatoes*, by grating them into cold water, was mixed with eight pounds of boiled potatoes, as good bread might be produced as from wheat flour.

The *bulb-bearing*, or *orange lily* (Lilium Bulbiferum), so called from producing bulbs in the axillas of each of the upper *leaves*, which, when the stalks decay, if planted, will grow, as well as some *bulbiferous grasses*, although the flowers are conspicuous, are said but seldom, or ever, to form prolific seeds, which are found when sown to vegetate.

The seeds of some plants, which also propagate themselves under ground by bulbs at their roots, will not ripen in this climate naturally, as the *snowdrop*; but are said to ripen, if the new bulbs be cut off early in the season; or if the propagation by their roots be retarded or prevented by confining them in garden-pots; and it is probable, that the seeds of *potatoes* might be rendered more perfectly ripe, and in consequence better for the cultivation of new varieties; if the young roots were taken away early

in the season from that, which is to bear seed; or if they were confined in garden pots.

It is also probable, that *Jerusalem,* or *ground-artichokes* (HELIANTHUS TUBEROSUS), might be induced to ripen its seeds in this country, if the new roots from a few of the forwardest plants were taken away early in the season, or if they were confined in garden pots. And if this plant could be propagated by seed, it might make a useful product in agriculture, as horses are very fond of the leaves, and swine of the roots; both of which are produced in great quantity; and as the latter contain much sugar, they must be very nutritive; and in respect to their culinary use are remarkably grateful to most palates, as well as nutritive, when cut into slices, and baked in beef or mutton pies; but are said to be flatulent in the bowels of those whose digestion is not very powerful; a property which might be worthy attention, where the propensity to fermentation is required, as in making bread with potatoes, or in the distillery.

It is also probable, that if the large new root-suckers of other perennial plants, which do not bear bulbous or tuberous roots, and which are late in ripening their seeds, or do not ripen them perfectly in this climate, were cut or torn off early in the season, as of the *palmated rhubarb* (RHEUM PALMATUM), or *mule rhubarb* (RHEUM HYBRIDUM); or if their roots were confined in garden-pots, that they might be more liable completely to ripen their respective seeds.

In transplanting *strawberries,* many of the roots being torn off, fewer leaf-buds, and consequent wires, are produced from the difficulty which their embryon caudexes find in producing new radicles over the old ones to supply nutriment to the wires, till they bend down and protrude roots into the ground at their other extremities, whence a great number of flower-buds are generated; on this account the roots of *strawberries* should generally be transplanted, or new ones from the wires should be cultivated, every third or fourth year, to prevent the too luxuriant growth of their wires; or a similar difficulty of producing wires or leaf-buds may be effected by crowding the roots of *strawberries* together, as some gardeners recommend; but I suppose by these means the fruit may become smaller from scarcity of nutriment, though more numerous.

A floor of bricks, or of stone, extended about two feet deep beneath the roots of wall trees, has been practised in some gardens from an idea, that the roots shoot themselves too deep into some unwholesome stratum of

earth; and it has been observed, that the *trees* became better fruit-bearers. In some situations it is possible, this might be the cause of the new prolific property of the trees; but I suspect it has occurred generally from the difficulty opposed to the number and elongation of the root-fibres, and consequently to the generation of the new caudexes of the embryon leaf-buds; whence a greater production of flower-buds ensued.

In similar manner it is asserted by one of the Linnean school, in the Amœnitates Academicæ, that some bulbous rooted plants, which seldom produce seeds in Sweden, will produce prolific seeds, if their roots be confined in a garden-pot, till they crowd each other; as those of the *Lily of the Valley* (CONVALLARIA). And that the *Orchis* will bear prolific seeds, if the new root early in the season be severed from the old one, which has put up the flower-stem.* This must occur, says Dr. Darwin, in the former case, from the difficulty which the plants find to generate new offsets at their roots, which are their viviparous progeny; and in the latter case from the new offset being destroyed; whence, in both situations, more nutriment is expended on the flower.

If the *orchis,* continues Dr. Darwin, could by such means be cultivated from seed on moist meadows or morasses, it might become a profitable article of husbandry; as when it is scalded in boiling water, and the peel rubbed off, it is sold by the name of salep, and might become a nutritive article of diet, like sago and vermicelli, if it could be propagated with less uncertainty.

On the same account it is probable, that confining the roots of *cucumbers* and *melons* in small garden-pots would stop the too luxuriant growth of their leaf-buds, and render them sooner oviparous (seed-bearing), if care be taken to supply them with water more frequently, and with sufficient nutriment by mixing with the water some of the carbonic black fluid, which has drained from a manure heap.

The *Greater and Lesser Periwinkle* (VINCA MAJOR ET MINOR), *Butter Burr* (TUSSILAGO PETASITES), and many other plants, as remarkable for the sterility of their seeds as their great increase by roots, might, in all probability, experience a similar effect, if under similar circumstances; their

* This law of Nature, however, does not appear general, for many plants producing offsets, or suckers, do accomplish the perfection of their seeds, as the *Houseleek* (SEMPERVIVUM TECTORUM), the *Stonecrop* (SEDUM), the *Couch-grass* (TRITICUM REPENS), the *Willow-herb* (EPILOBIUM), which last is a great runner, &c. &c.; and *seeds* also have been found *prolific* in the *Lilies of the Valley*, and the several kinds of *Orchises*, at least in this country.

supposed sterility, therefore, should seem to result chiefly from the peculiarity of their situation and constitutions, and not from any real defect in the formation of all, or any of their parts of fructification, as has sometimes been ingeniously conjectured by some botanists.

The *pubescent Poison-oak* (Rhus Toxicodendron), like its congener the *smooth-rooting Poison-oak* (Rhus radicans), trails along the ground, and has, like that shrub, the property of sending down radicles into the earth, by which the plant admits of great increase, in any of the summer months.

In such situations, however, I have not seen it produce seeds so readily as in drier and more pinching places, where it loses, in a great degree, its radicating principle, grows more stiff and robust, and produces annual crops of pale yellow striated berries. There is a remarkable instance of this kind now existing in a *wall,* belonging to the Physic Garden of the company of Apothecaries at Chelsea, out of a chink in the side of which, and near the ground, grows a strong plant of this *Rhus,* that has prospered there ever since the time of the celebrated *Miller,* and which Mr. *Fairbairn,* the company's present gardener, obligingly assured me was what *Miller* called the second *Toxicodendron,* in his Gardener's Dictionary; it is, in all probability, the identical plant from which the description in that well-known work was made; it *seeds* annually, but none of its lower shoots exhibit the least *radicating* propensity, although other plants of the same kind, in the shady parts of the same garden, have that quality in great perfection, but I believe they rarely produce seeds; so much do local circumstances affect and alter the most permanent and distinguishing characters of vegetables.

I believe it is pretty generally known to gardeners, and others concerned in the pleasant and instructive employment of horticulture, says Dr. Alderson, that many other fibrous plants, which, like the *Rhus Toxicodendron,* possess the power of increasing themselves in any considerable degree by their roots, have that property *materially* lessened when the place they grow in happens to be dry and poor, for Nature has chiefly allotted them rich and moist habitations, and with her usual care, constructed their constitutions accordingly; the alteration such plants undergo, in such a soil, is doubtless in the direction of their juices, which (being fewer) appear to pass by the lower and less noble parts (they had before rendered luxuriantly radicant or prolific), and mount upwards by a natural and almost instinctive impulse, to feed and mature, with collected force, the infant germens (seed-vessels) which they had before too sparingly supplied with nourishment.

SECT. XXXII.

HOW TO GENERATE THE BEST KIND OF SEEDS.

Ye trees, that fill the rural scene;
Ye flowers, that o'er th' enamell'd green
In native beauty reign;
O praise the Ruler of the skies,
Whose hand the genial sap supplies,
And clothes the smiling plain.

Merrick.

The most healthy plants must be chosen,* and those which are most early in respect to the season; these should be so insulated, as to have no weak plants of the same species, or even genus, in their vicinity, lest the fecundating dust of weaker plants should be blown by the winds upon the stigmata of the stronger, and thus produce a less vigorous progeny.

Where new varieties are required, the male dust of one good variety, as of the *nonpareil apple,* should be shed upon the stigmas of another good variety, as of the *golden-pippin*; and it is probable some new excellent variety might be thus generated.†

Mr. *Knight* has given a curious experiment of his impregnating the stigmas of the pea-blossoms of one variety with the farina of another. He says, Treatise of Apple and Pear, p. 42, " Blossoms of a small *white garden-pea,* in which the males had previously been destroyed, were impregnated with the farina of a large *clay-coloured kind with purple blossoms.* The produce of the seeds thus obtained were of a *dark grey colour,* but these having no fixed habits, were soon exchanged by cultivation into a numerous variety of very large and extremely luxuriant *white ones*; which were not only much larger and more productive than the *original white ones,* but the

* When farmers reverse this rule, and choose the leanest seed, it is for poor land; for large good seeds send forth more tillows (shoots) than the ground, by reason of its poverty, could maintain, and all would perish, and soon be exhausted.

† Botany is so much a circle, that it is hardly possible to begin any where without being sometimes obliged to anticipate, speaking *now* of the sexes in plants, which the reader will have the goodness to excuse.

number of seeds in each pod was increased from seven or eight to eight or nine, and not unfrequently to ten. The newly made *grey kinds* I found were easily made *white* again by impregnating their blossoms with the farina of *another white kind.* In this experiment the seeds, which grew towards the point of the pod, and were by position first exposed to the action of the male, would sometimes produce seeds like it in colour, whilst those at the other end would follow them.

" In other instances the whole produce of the pod would take the colour of one or other of the parents; and I had once an instance in which two peas at one end of a pod produced white seeds like the male, two at the other end grey ones like the female, and the central seeds took the intermediate shade, a clay colour. Something very similar appears to take place in animals, which produce many young ones at a birth, when the male and female are of opposite colours. From some very imperfect experiments I have made, I am led to suspect that considerable advantage would be found to arise from the use of new or regenerated varieties of wheat; and these are easily obtained, as this plant readily sports in varieties, whenever different kinds are sown together."

To collect good seeds, according to the observations of Mr. Cooper of Philadelphia, consists not in procuring new seeds from distant places, as is generally supposed, but in selecting the best seeds and roots of his own; which though he has continually sown or planted them in the same soil, every article of his produce is greatly superior to those of any other person, who supplies the market; and they seem still in a state of improvement. He believed that no kind of relationship would degenerate the breeds of vegetables, and therefore adopted the plan of Mr. *Bakewell* in England in respect to quadrupeds, who continued to improve his flocks and herds by the marriages of those in which the properties he wished to produce were most conspicuous, without regard to consanguinity.

Mr. Cooper was led to his present practice, which he began more than forty years ago, by observing that vegetables of all kinds were very subject to change with respect to their time of coming to maturity, and other properties, but that the best seeds never failed to produce the best plants. Among a great number of experiments he particularly mentions the following.

" About the year 1746 his father procured seeds of the *long watery squash,* and though they have been used upon the farm ever since that

time without any change, they are at this time better than they were at the first.

" His *early peas* were procured from London in the year 1756, and though they have been planted on the same place every season, they have been so far from degenerating, that they are preferable to what they were then. The seeds of his *asparagus* he had from New York in 1752, and though they have been planted in the same manner, the plants are greatly improved.

" It is more particularly complained of, that *potatoes* degenerate when they are planted from the same roots in the same place. At this Mr. *Cooper* says, he does not wonder, when it is customary with farmers to sell or consume the best, and to plant from the refuse; whereas having observed that some of his plants produced potatoes that were larger, better shaped, and in greater abundance than others, he took his roots from them only; and the next season he found that the produce was of a quality superior to any that he had ever had before. This practice he still continues, and finds that he is abundantly rewarded for his trouble.

" Mr. *Cooper* is also careful to sow the plants, from which he raises his seed, at a considerable distance from any others. Thus, when his *radishes* are fit for use, he takes ten or twelve, that he most approves, and plants them at least one hundred yards from others that blossom at the same time. In the same manner he treats all his other plants, varying the circumstances according to their nature.

" About the year 1772 a friend of his sent him a few grains of a small kind of *Indian corn,* not larger than goose shot, which produced from eight to ten ears on a stalk. They were also small, and he found that few of them ripened before the frost. Some of the largest and earliest he saved, and planted them between rows of a larger and earlier kind, and the produce was much improved. He then planted from those that had produced the greatest number of the largest ears, and that were the first ripe, and the next season the produce, with respect to quality and quantity, was preferable to any that he had ever planted before.

" The common method of saving seed-corn by taking the ears from the heap is attended, he says, with two disadvantages; one is the taking the largest ears, of which in general only one grows on a stalk, which lessens the produce; and the other is taking ears that ripen at different times.

" Many years ago Mr. *Cooper* renewed all the seed of his winter grain

from a single plant, which he had observed to be more productive, and of a better quality than the rest; which he is satisfied has been of great use. And he is of opinion, that all kinds of garden vegetables may be improved by the methods described above, particular care being taken that different kinds of the same vegetables do not bloom at the same time, near together; since by this means they injure one another."—Vide Communications to the Board of Agriculture.

The choice of the seed intended to be sown, is an object of greater importance than many farmers seem to imagine. It is not sufficient that the finest grains be chosen for this purpose, unless they be likewise very clean. Such seed is not difficult to be got from land cultivated according to the principles of the new husbandry: but we seldom find corn free from the seeds of weeds when it has been raised in the common way.

It is natural to suppose, that the grains of stunted and sickly corn necessarily partake of the weakly disposition of the plant which produced them, and that their productions cannot be so fine as those which grow from the seeds of strong and healthy plants. For this reason Mr. Tull advises to take the seed-corn from a richer soil than that in which it is to be sown; and rather from that in perfect tilth, than from land which has been less carefully cultivated. Dr. *Fordyce* seems to be of the same opinion, when he says, seeds taken from plants in a rich soil branch out more than those taken from plants in a poorer soil. This appears rational: and though the contrary opinion is almost generally received, yet more may reasonably be expected from the productions of fine good seeds, which are full of vigour, and well conditioned, than from poor, feeble, shrivelled seeds.

For the procurement of good seeds I would advise the following methods.

One method which I have practised with seeds in general, and would advise, is as follows. Let a beam, two feet square, be laid across the barn-floor. Let the thresher take out of a loosened sheaf of corn an handful, and holding the straws at some distance from the ears, give the parcel one or two strokes against the beam, when the best grain will fly out only, and these will not be bruised, as too often happens from the flail, and the remaining corn will be subjected to the usual mode of threshing out for domestic uses.

Another excellent way to separate the fullest, and consequently heaviest grains, which are undoubtedly the fittest for seed, from those which are of

less value for that purpose, and at the same time to clear them from many seeds of weeds, is, to make a stout man, with a broad wooden shovel, throw the corn with all his force towards an opposite corner of the barn, or rather of a large boarded room, which is fittest for this work. All the light, small, shrivelled grain, unfit for sowing, and the seeds of cockle, &c. not being so heavy as the solid corn, will fall short, and lie nearest to the man who throws them; while such as are large, plump, and weighty,* outflying all the rest, are separated widely, and may easily be gathered up. Experience will shew the vast advantages of seed thus chosen.

---

* It is, however, the opinion of many, that *small* seeds are equally advantageous as the larger, by which a great saving is made; and it must be allowed, that as weakly children often grow up to vigorous men, so the smaller seeds will sometimes answer well; but it must be confessed, that such trials are frequently hazardous.

SECT. XXXIV.

HOW TO DETERMINE THE GOODNESS OF SEEDS.

Leave the gay town for scenes more truly gay,
Air unpolluted, and unclouded day:
On the green hillock snuff the passing gales,
Or catch the fragrance of the flow'ry dale.
The passing seasons of the year remark,
From hoary Winter, cheerless, dreary, dark,
To jocund Spring, where, dress'd in rich array,
All nature wantons in the sweets of May.
Admire the rip'ning fruits of Summer's reign,
And Autumn, fraught with loads of golden grain;
Pleasures like these enjoy, their blessings own,
And health shall deck thee with her envy'd crown.

SMYTHSON.

THE weighing a given measure of them may generally be esteemed a criterion, as it is known, that when seeds are put into cold water, those which are less perfect are liable to swim, and the sound ones to sink; thus the imperfect seeds of *rye-grass* and of *clover* may be detected by throwing a spoonful of them into water; but the seeds of rye-grass are said to be frequently adulterated by a mixture of the seeds of *twitch* or *dog's grass*, which can only be discovered by an experienced eye. This even is said to be a test of the goodness of *malt*; as those grains, which are not perfectly germinated, will swim with one end upwards, I suppose the root end; and those which are perfectly germinated swim on their side, whilst the sound ungerminated barley sinks in water.

It is therefore a proper criterion of good seed-wheat to cast it into salt and water, just so saline as to float an egg; as the more salt is dissolved in the water, the heavier it becomes; and hence none but sound grains of wheat will sink in this brine; and that which swims is properly rejected. This rejection of the light grains by steeping wheat in brine is probably of greater consequence to the ensuing crop, than the adhesion of any salt to the grain, which has been believed to destroy the eggs of insects supposed to adhere to it, or to fertilize the soil.

The weight of a given measure of corn will also with considerable certainty discover the quantity of husk or bran contained in it, compared to the quantity of flour; as that grain, which is cut too early, or which is otherwise not quite ripe, as happens in wet seasons, shrinks in the barn or granary, and becomes wrinkled, and has thus a greater proportion of skin or bran than that which has been more perfectly ripened, and will hence weigh lighter in proportion.

A test of this kind may enable us to determine whether *peas* and *beans*, or *oats*, are preferable, in respect to economy, as provender for horses. A strike or bushel of *oats* weighs perhaps forty pounds, and a strike or bushel of *peas* and *beans* perhaps sixty pounds; and as the skin of *peas* and *beans* is much less in quantity than that of *oats*, I suppose there may be at least fifteen pounds of flour more in a strike of *peas* and *beans* than in a strike of *oats*. There is also reason to believe, that the flour of *beans* is more nutritive than that of *oats*, as appears in the fattening of hogs; whence, according to the respective prices of these two articles, I suspect that peas and beans generally supply a cheaper provender for horses than oats, as well as for other domestic animals.

But as the flour of *peas* and *beans* is more oily, I believe, than that of *oats*, it may in general be somewhat more difficult of digestion; hence when a horse has taken a stomach full of *peas* and *beans* alone, he may be less active for an hour or two, as his strength will be more employed in the digestion of them, than when he has taken a stomach full of *oats*. According to the experiment of a German physician, who gave to two dogs, which had been kept a day fasting, a large quantity of flesh food, and then taking one of them into the fields hunted him with great activity for three or four hours, and left the other by the fire. An emetic was then given to each of them, and the food of the sleeping dog was found perfectly digested, whilst that of the hunted one had undergone but little alteration.

Another way of distinguishing light corn from heavy is by winnowing; as the surface of the light grains being greater in proportion to their solid contents, they will be carried further by the current of air which is produced by the van; though the heavy grains would roll further on the floor after rolling down a grate to separate the dust; because their vis inertiæ would carry them further after they are put in motion; and their surfaces would be resisted by the air no more than those of the lighter grains.

Finally, there is reason to believe that a progressive improvement of

many seeds exists, during the warmer days of winter, in our granaries, which probably consists in the process of the conversion of mucilage into starch; in the same manner as the harsh juices of crab-apples, and of austre pears, are continually changing into sugar during the winter; both which processes are probably in part chemical, like the slow but perpetual change of sugar into vinous spirit, when the juices of sweeter apples and pears, or grapes, are put into bottles in the manufacture of cyder, perry, and wine.

This improvement of *wheat,* and of *barley,* and of *oats,* is well known to the baker, the maltster, and the horse-dealer; as better bread is made from old *wheat,* and *barley* is converted into better malt in the vernal months; and horses are believed to thrive better, and to possess more vigour, when they are fed with old than with new *oats.*

Another circumstance of consequence was first discovered by chance by M. Chateauvieux, and was confirmed by repeated experiments, always attended with equal success. In his experimental sowings, he commonly used *wheat* taken from the heap in the granary, and sometimes corn picked out of the ears, the moment before it was sown. He counted the number of grains, of both sorts, and found a very considerable difference in their productions. What was picked out of the ears always rose extremely well; scarce a grain ever missed; whereas, numbers of those taken from the heaps never sprouted at all. He did not perceive this difference at first, but at last it struck him; and he relates the fact without pretending to account for it. The experiment itself may be of real use, by shewing, that instead of threshing the wheat intended for seed, at any time, it ought not to be threshed till within a few days of its being sown.